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STUDY OF PARACHUTE FORCES AND CANOPY PRESSURE DISTRIBUTION MEASURED IN A SUBSONIC WIND TUNNEL UNDER INFINITE MASS CONDITIONS

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13. ABSTRACT

For the purpose of parachute canopy stress analysis during the period of inflation, the pressure distribution measured on a ring-slot parachute model is related to the instantaneous parachute force. The correlation of pressure and force data is based on test results established at the Deutsche Forschungsanstalt fuer Luft-und Raumfahrt (DFLR), Braunschweig, Germany.

The final pressure-force-time relationship incorporate individual as well as averaged test data. A fair agreement could be shown between measured forces and those obtained from numerical integration of differential pressure over the canopy surface.

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FOREWORD

This report was prepared by the Department of Aerospace Engineering and Mechanics of the University of Minnesota in compliance with U.S. Air Force Contract No. F33615-68-C-1227, "Theoretical Deployable Aerodynamic Decelerator Investigations," Task 606503, "Parachute Aerodynamics and Structures," Project 6065, "Performance and Design of Deployable Aerodynamic Decelerators." The work on this project was performed between 1 August 1969 and 15 August 1971.

The study under this contract was sponsored jointly by U.S. Army Natick Laboratories, Department of the Army, and the Air Force Systems Command, Department of the Air Force, with Messrs. Edward J. Giebutowski, U.S. Army, and James H. DeWeese, USAF, being the representatives. The contract was administered by the Recovery and Crew Station Branch, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio, with Mr. James H. DeWeese (FER) as project engineer.

The study was conducted in cooperation with Mr. Robert A. Noreen and several students of Aerospace Engineering at the University of Minnesota. The authors wish to express their gratitude to all who rendered their services to the accomplishment of this work, especially to Mr. DeWeese for his cooperation and guidance.

This report was submitted by the authors in August, 1971.

This technical report has been reviewed and is approved.

George A. Solt, Jr.

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Air Force Flight Dynamics Laboratory

ABSTRACT

For the purpose of parachute canopy stress analysis during the period of inflation, the pressure distribution measured on a ringslot parachute model is related to the instantaneous parachute force. The correlation of pressure and force data is based on test results established at the Deutsche Forschungsanstalt fuer Luft- und Raumfahrt (DFLR), Braunschweig, Germany.

The final pressure-force-time relationships incorporate individual as well as averaged test data. A fair agreement could be shown between measured forces and those obtained from numerical integration of differential pressure over the canopy surface.

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ILLUSTRATIONS (CONT.)

TABLES

SYMBOLS

a	photographic shape parameter (from Ref 1)
b	photographic shape parameter (from Ref 1)
$C_{D_{av}}$	$(C_DS)_{av}/S_{measured}$
$(C_DS)_{av}$	$\frac{1}{n}\sum_n \frac{F_n}{q_n}$
C_{p_d}	measured differential pressure coefficient = $C_{p_i} - C_{p_e}$
$\bar{C}_{p_d}$	replacement pressure coefficient defined by averaged characteristic values of C_{p_i} and C_{p_e}
$\bar{C}_{p_{d,measured}}$	replacement pressure coefficient defined by averaged characteristic values of C_{p_d}
$\bar{\bar{C}}_{p_d}$	replacement pressure coefficient defined by averaged characteristic values of C_{p_i}, C_{p_e}, and C_{p_d}
C_{p_e}	measured external pressure coefficient = $\Delta p_e/q$
$\bar{C}_{p_e}$	replacement pressure coefficient defined by averaged characteristic values of C_{p_e}
C_{p_i}	measured internal pressure coefficient = $\Delta p_i/q$
$\bar{C}_{p_i}$	replacement pressure coefficient defined by averaged characteristic values of C_{p_i}
D	aerodynamic drag force
D_o	nominal diameter of parachute canopy
f	cloth stress
F	instantaneous measured parachute force
$\bar{F}$	instantaneous averaged measured parachute force
$\bar{\bar{F}}$	instantaneous calculated parachute force based on replacement pressure coefficient $\bar{C}_{p_d}$
F_c	constant force = $q\left[\frac{1}{n}\sum_n \frac{F_n}{q_n}\right] = q(C_DS)_{av}$
F_{calc}	instantaneous calculated parachute force based on C_{p_d}

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F^*	dimensionless force = F/F_c for F_{calc}/F_c
q	dynamic pressure
r	photographic shape parameter (from Ref 1)
r_b	gore bulge radius
r^*	photographic shape parameter (from Ref 1)
r_1	upper radius of conical frustum approximating segment of canopy surface
r_2	lower radius of conical frustum approximating segment of canopy surface
R	radial distance on canopy, calculated force ratio
R_o	nominal radius of parachute canopy
S	area
t	time
t_f	filling time
t'	time at which maximum projected diameter occurs, as identified in Ref 1
t^*	time at which steady state values of shape parameters first occurs, as identified in Ref 1
T_o	dimensionless time = t/t' or t/t^*
$\overline{T}_o$, $\overline{t/t'}$	time scale for replacement pressure coefficients $\overline{C}_{p_d}$, $\overline{C}_{p_{d,measured}}$, $\overline{C}_{p_e}$, $\overline{C}_{p_i}$
$\overline{\overline{T}}_o$, $\overline{\overline{t/t'}}$	time scale for replacement pressure coefficient $\overline{\overline{C}}_{p_d}$
Δp	net pressure differential
ΔR	slant height of conical frustum approximating segment of canopy surface
ΔS	segment of canopy surface used in numerical integration
λ_G	geometric porosity
θ	angle between flow velocity and normal to canopy surface

ς photographic shape parameter (from Ref 1)

ς^* photographic shape parameter (from Ref 1)

I. INTRODUCTION

The Recovery and Crew Station of the Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, suggested a scheme by which the pressure distribution of a parachute canopy in subsonic flow is presented as a function of the instantaneous parachute force. This concept is carried out in the following in a number of steps.

The knowledge of the pressure distribution related to the parachute force characteristics is very useful because all known parachute stress analyses incorporate the term of differential pressure between the inner and outer surfaces of the parachute canopy, whereas the parachute force can be calculated independently from one of the advanced parachute opening theories. A correlation between parachute force and pressure distribution then provides the background information for a canopy stress analysis.

In accordance with this scheme, the first objective of this study is the establishment of the ratio between the instantaneous and the steady state parachute force as a non-dimensionalized function $F^* = f(T_o)$ related to the coefficient of differential pressure C_{p_d} as a function of time, $C_{p_d} = f(T_o)$. The second step in this scheme is a correlation between the pressure differential C_{p_d} and force ratio $C_{p_d} = f(F^*)$.

Numerical values for the determination of these functions are given in Ref 1 and in additional information provided by the Air Force Flight Dynamics Laboratory (Ref 2). The indicated analysis was carried out for a solid flat parachute and a ringslot parachute with a measured geometric porosity of 19.7 per cent. Both parachutes had nominal diameters of approximately 4 ft.

The pressure and force data of Ref 1 are presented as functions of time in seconds, which for the purpose of this study had to be transferred to a dimensionless time, preferably $T = t/t_f$ (Ref 3).

Unfortunately, the time t_f was not used or mentioned in Ref 1. However, characteristic times were given which are related to the instances at which the steady state mean values of the shape parameters are reached for the first time, t_*, and when the canopy is inflated to its maximum diameter. In the following study these times are called t^* and t', respectively. The time t' was available for all test data, whereas t^* was given merely for certain cases. Since t^*

and t' are nearly alike, the ratios t/t* and t/t' are called T_o in the following text. However, for clarity the individual symbols are retained in Figures and tables. (Values of t/t* were used when available).

In order to be sure of the reliability of the basic data and to estimate accuracy of the final pressure-force functions, the following check was made. After obtaining the pressure-time and force-time functions, the drag component of the pressure function was integrated over the parachute canopy profiles as given in Ref 1. The total area of the canopy was obtained by measuring the parachute models actually used in the tests of Ref 1. The calculated aerodynamic drag forces were then compared with the measured forces. This check was made first for individual runs and then with data averaged from all tests reported in Ref 1.

These checks indicated that for the solid flat parachute the measured and calculated maximum and steady state forces deviated from each other by factors between 1.3 and 2.4. Therefore, the analysis of the solid flat parachute was not carried out up to the final pressure-force functions.

The same procedure, applied to the data of the ringslot parachute, showed discrepancies up to 20%. Since this was the first attempt of pressure-force correlation (no publication on this subject has been found by the authors), the analysis was carried out anyway and finalizing pressure-force functions were established.

In order to preserve the main train of thought, many numerical details are omitted from the basic text and are presented in graphs and tables in the appendix.

II. PRESSURE AND FORCE VALIDATION FOR SOLID FLAT AND RINGSLOT PARACHUTES

A. Data Analysis of Individual Tests

The pressure measurement presented in Ref 1 was made by means of electronic sensors. Their location on the parachute model canopies are shown in Fig 1. The experimental data of the solid flat parachute were analyzed for velocities of 70, 100, 130, and 160 fps. The results of this analysis are presented in four sets of figures showing in sequence the differential pressure coefficient C_{p_d} vs T_o, C_{p_d} vs R/R_o with T_o as parameter, and the measured and calculated instantaneous forces ratioed to steady state force F_c vs time. Finally, the fourth figure in each set shows a comparison of the calculated and measured forces near the force maximum during the inflation and at steady state. Figures 2 to 17 show the results of these efforts.

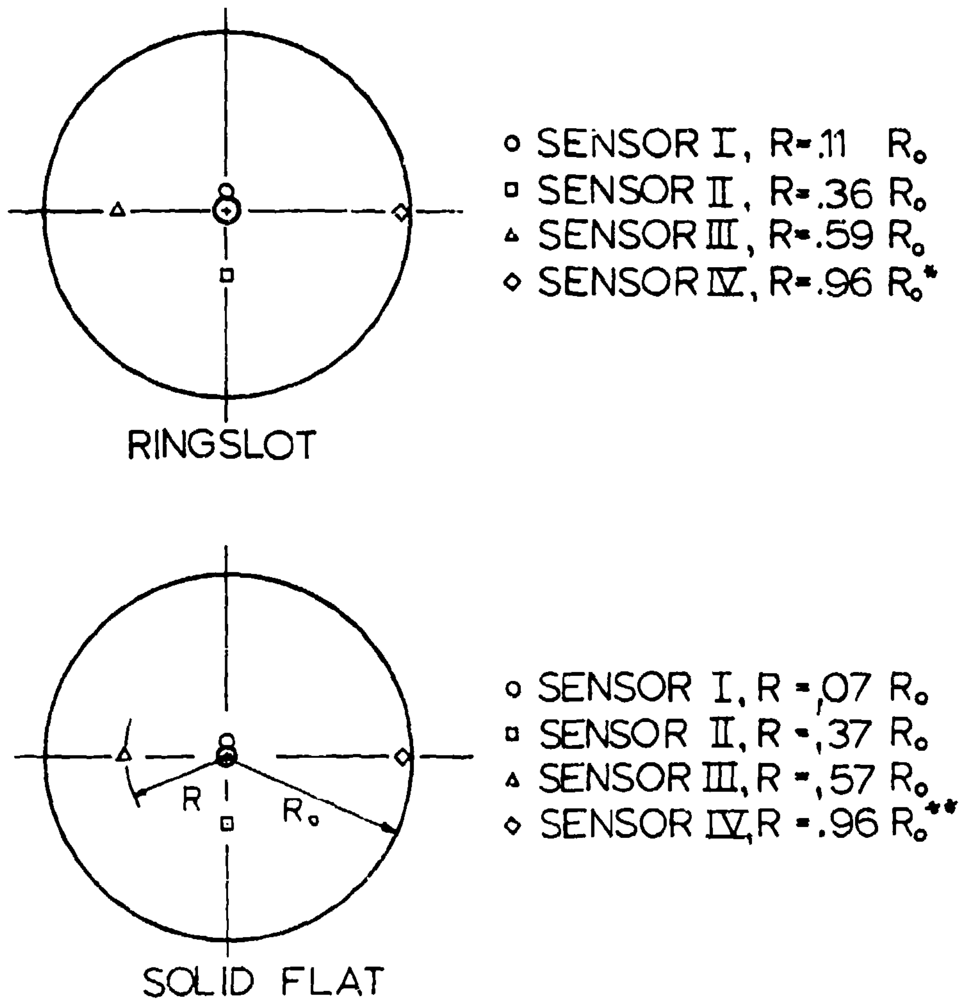
For the purpose of this study the comparison of the measured and calculated forces during inflation and at steady state are of particular interest. As can be seen from Figs 4 and 5, 8 and 9, 12 and 13, and 16 and 17, the deviations vary from 30 to 144 per cent. In view of such a degree of discrepancy, an analysis as outlined in the introduction may not be justified. However, before a final decision was made another check with averaged data of all tests was accomplished in the same manner.

A similar check was carried out for the ringslot parachute as shown in Figs 18 to 33. One notices that the calculated and measured forces agree much better, particularly in the regions of maximum force development and at steady state. In the case pertaining to the velocity of 70 fps, a small phase shift was introduced which was considered justifiable in view of the complicated electronic measurements and data recordings. In these regions the discrepancies range from -2% to +24%. This result was considered encouraging and an additional check was made with values averaged over all data of all available recordings.

The mode of integration providing the calculated parachute forces as well as an accuracy account of the integration method is given in the Appendix, Section I.

B. Replacement Curves Based on Averaged Values of all Available Experimental Data

In order to establish the broadest possible generalization of the pressure and force data, it appeared desirable to use all information given in Refs 1 and 2.



*DIMENSIONS MEASURED FROM PARACHUTE MODEL

**DIMENSIONS APPROXIMATED FROM PARACHUTE MODEL AND SKETCHES, REF 1

Fig 1 Sensor Locations

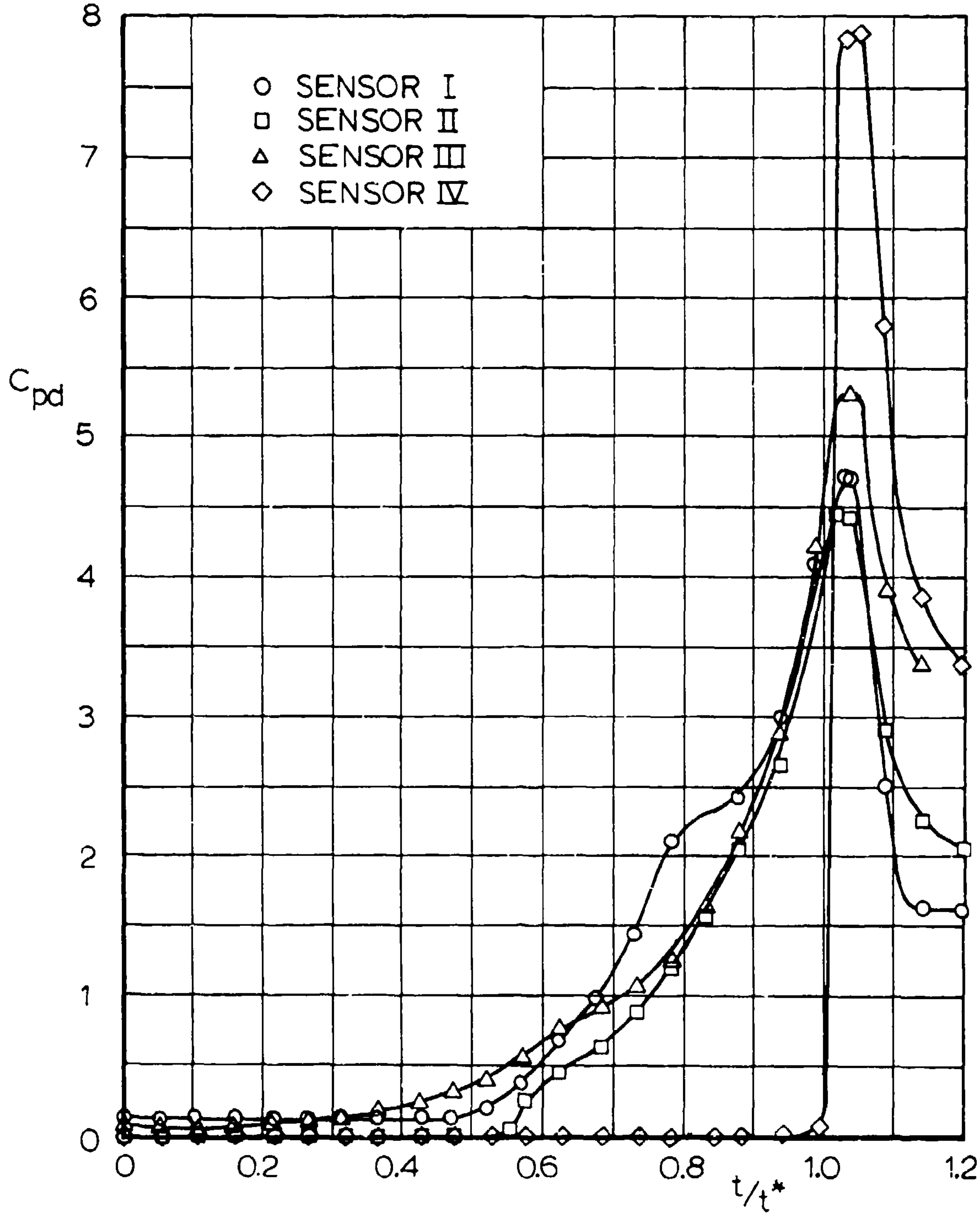


Fig 2 Measured Differential Pressure Coefficient vs Time; Solid Flat Circular Parachute, V_o = 70 ft/sec (Based on Ref 1, Run 182)

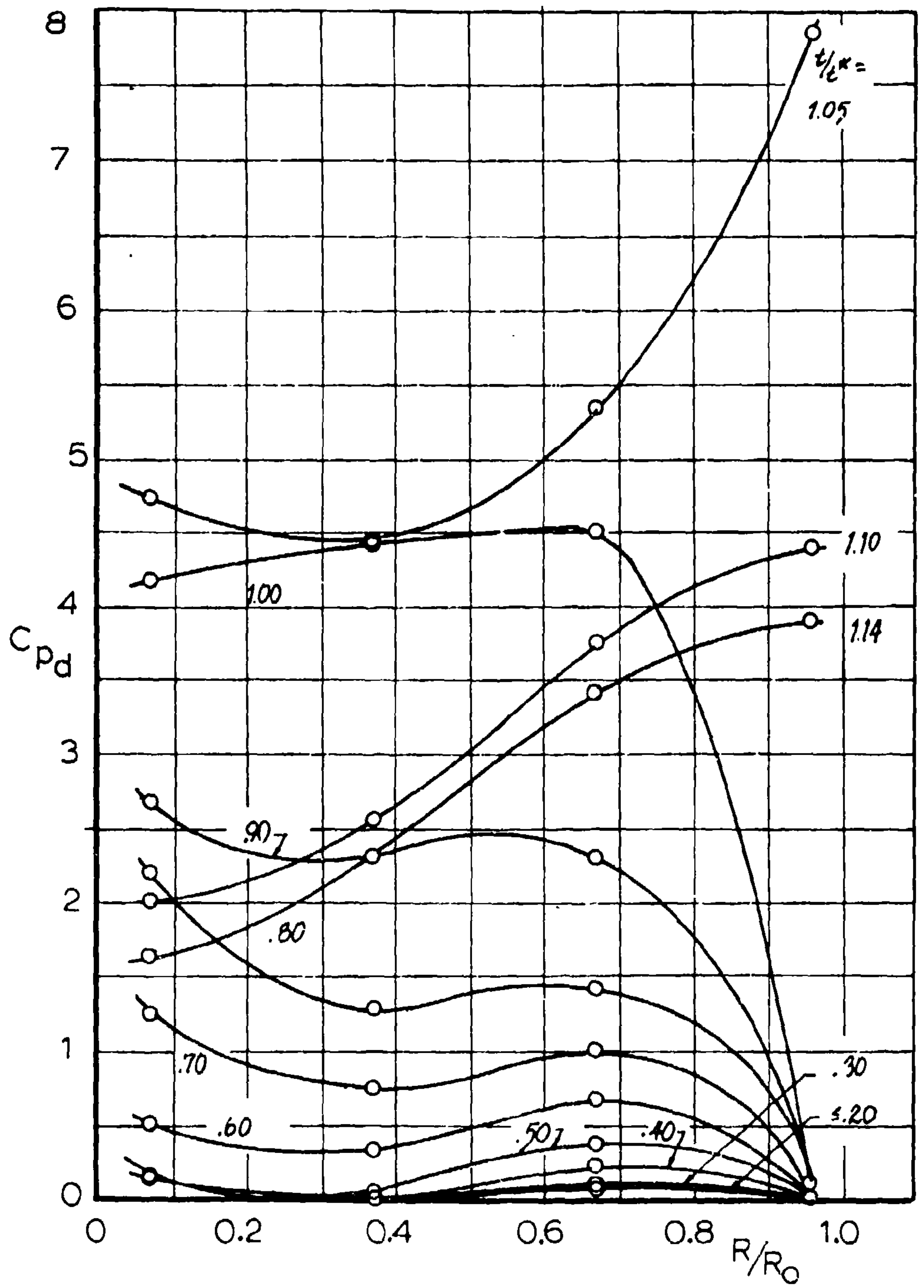


Fig 3 Measured Differential Pressure Coefficient vs Location; Solid Flat Circular Parachute, $V_o = 70$ ft/sec (Based on Ref 1, Run 182)

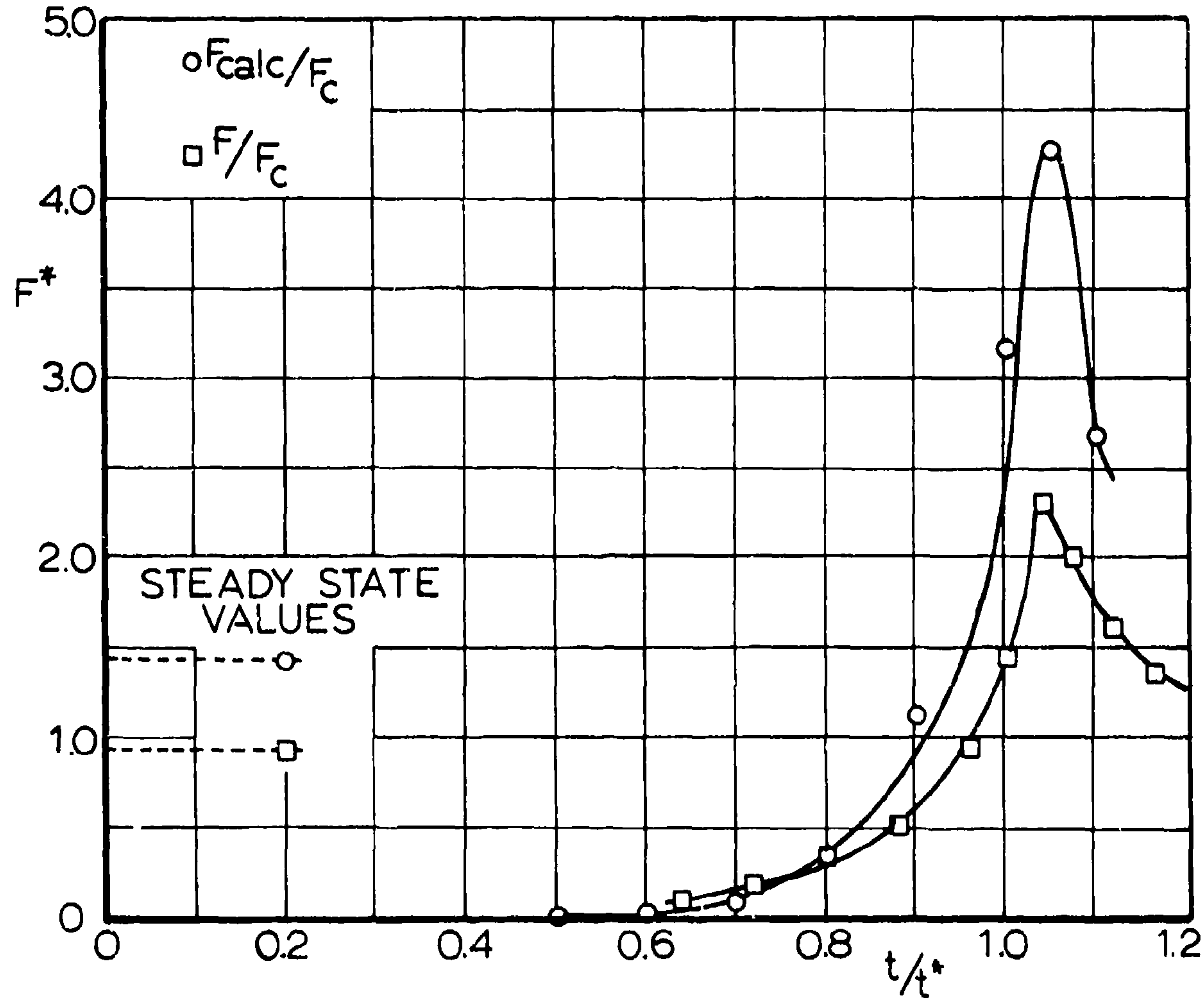


Fig 4 Dimesionless Measured and Calculated Instantaneous Forces; Solid Flat Circular Parachute, $V_o = 70$ ft/sec (Based on Refs 1,2; Run 182)

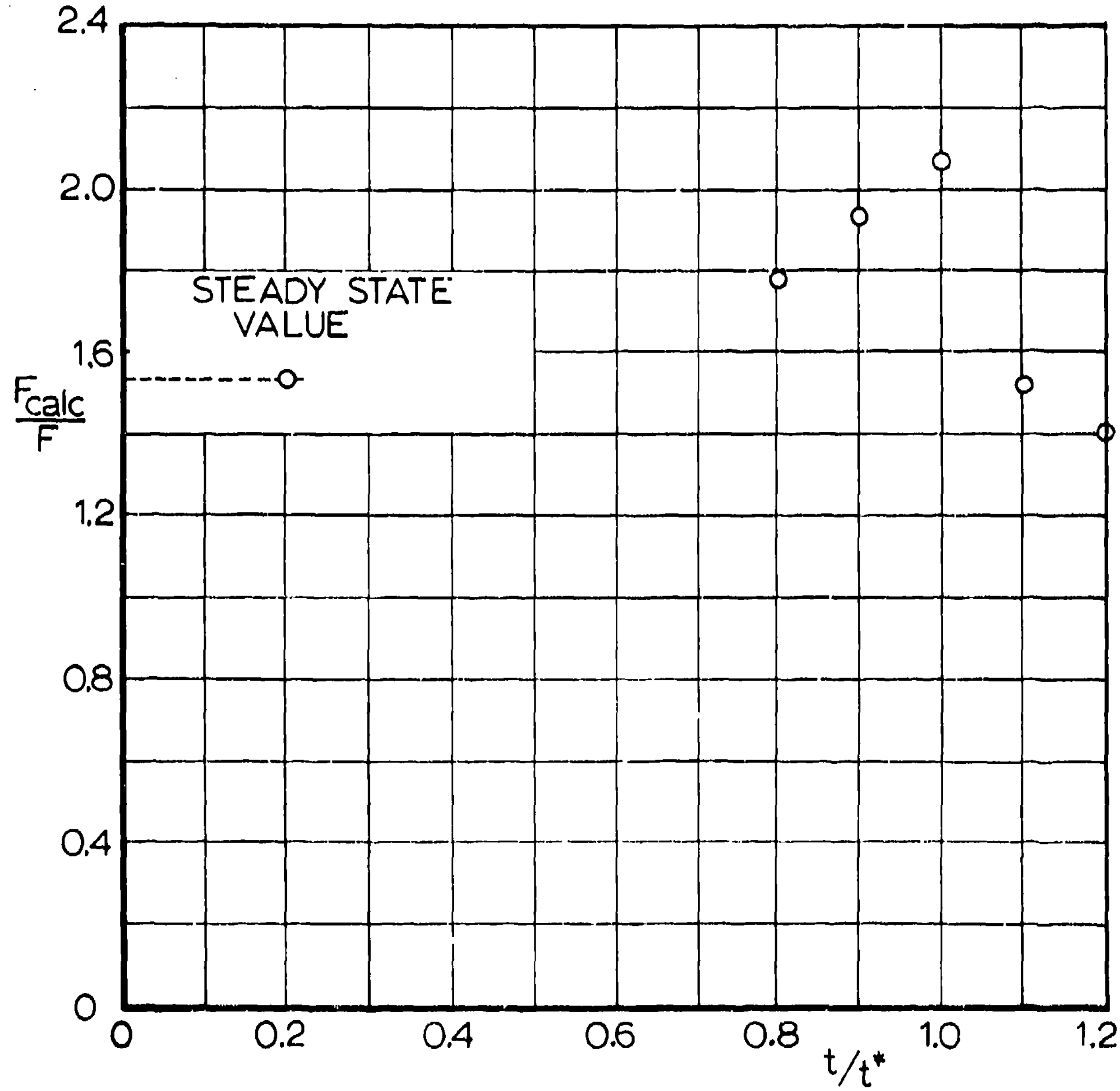


Fig 5 Ratio of Calculated and Measured Instantaneous Forces; Solid Flat Circular Parachute, $V_0 = 70$ ft/sec (Based on Refs 1, 2, Run 182)

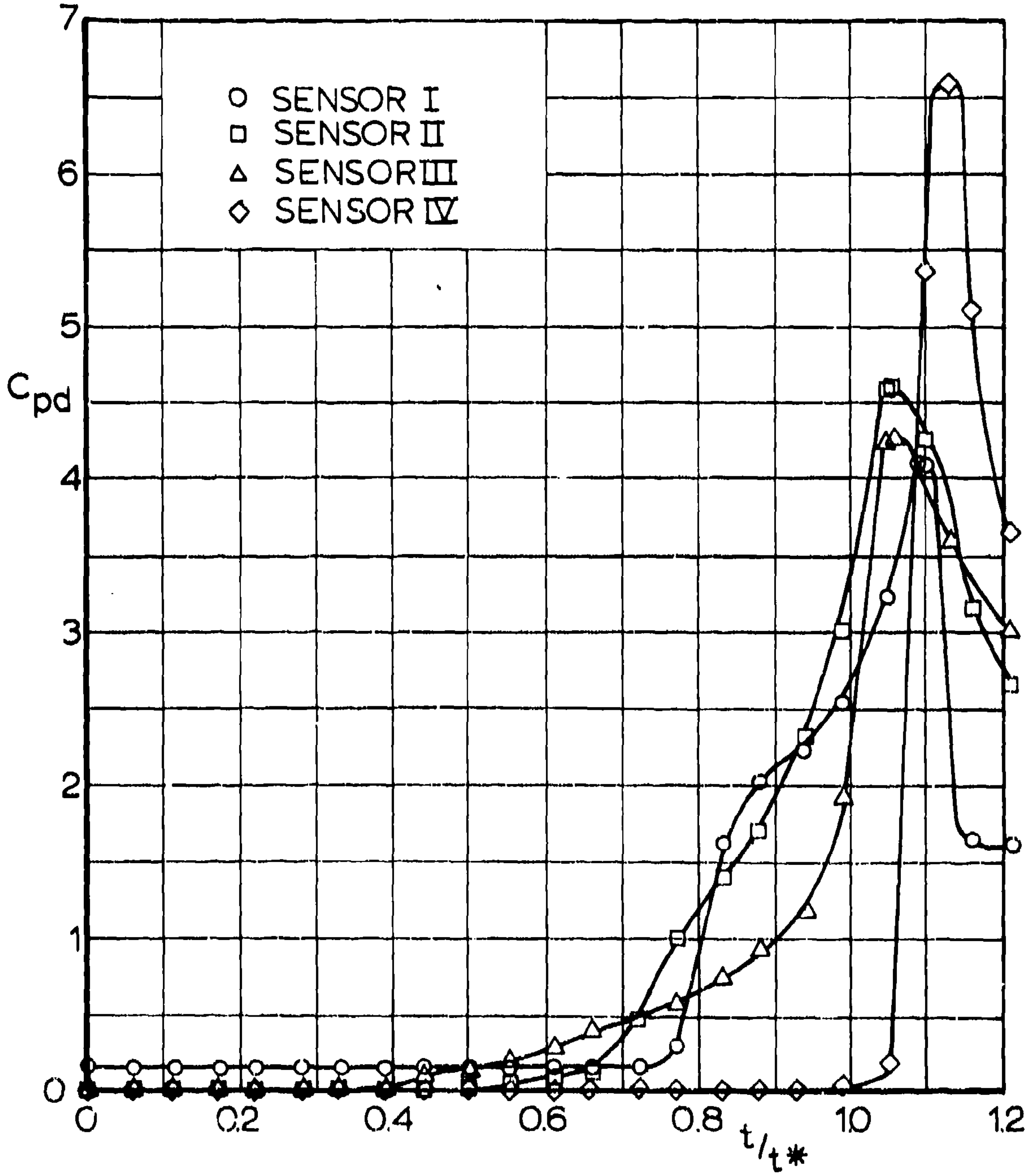


Fig 6 Measured Differential Pressure Coefficient vs Time; Solid Flat Circular Parachute, V_o = 100 ft/sec (Based on Ref 1, Run 183)

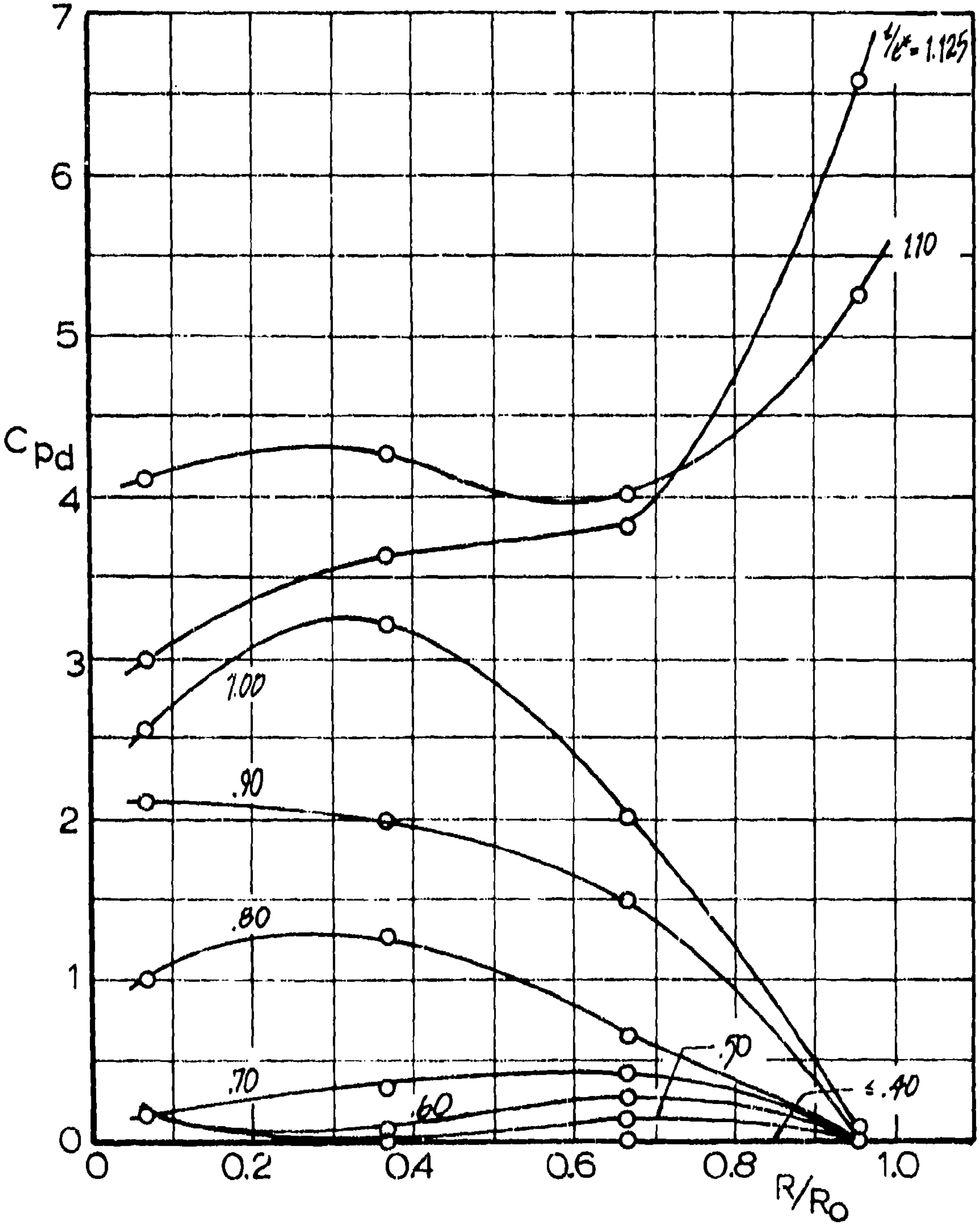


Fig 7 Measured Differential Pressure Coefficient vs Location; Solid Flat Circular Parachute, V_o = 100 ft/sec (Based on Ref 1, Run 183)

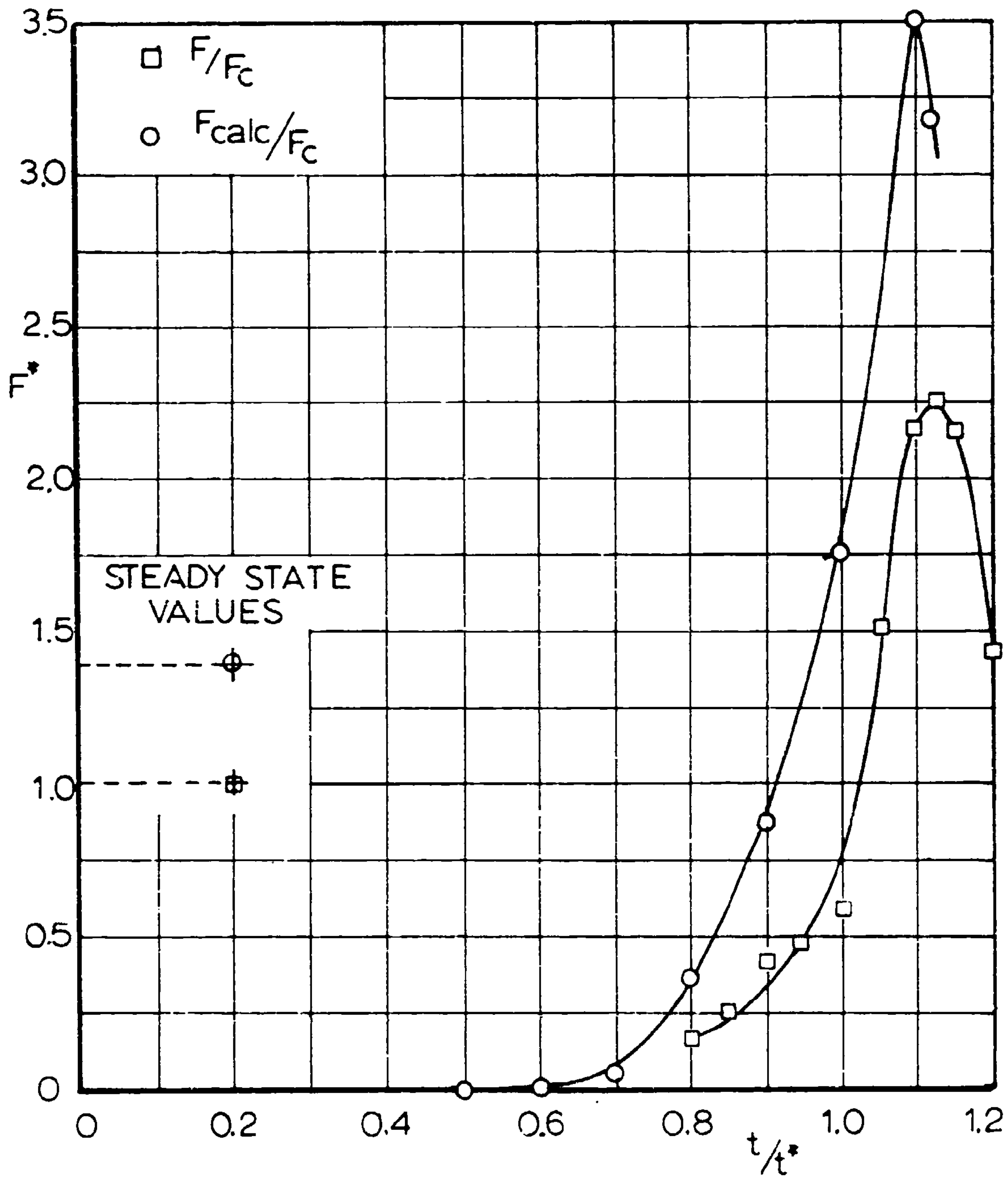


Fig 8 Dimensionless Measured and Calculated Instantaneous Forces; Solid Flat Circular Parachute, V_0 = 100 fps (Based on Refs 1,2; Run 183)

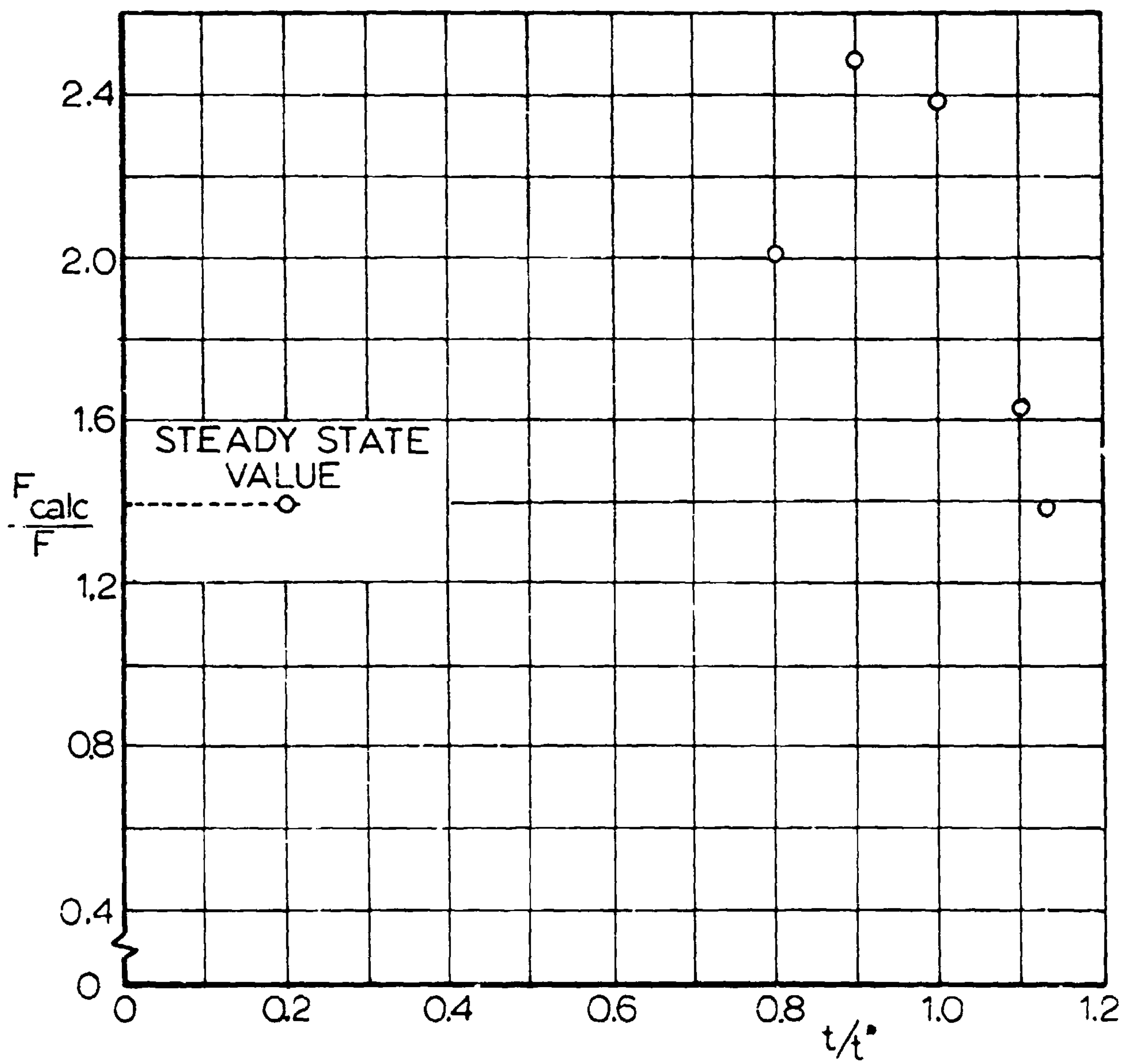


Fig 9 Ratio of Calculated and Measured Instantaneous Forces; Solid Flat Circular Parachute, V_o =100 ft/sec (Based on Refs1 , 2 ; Run 183)

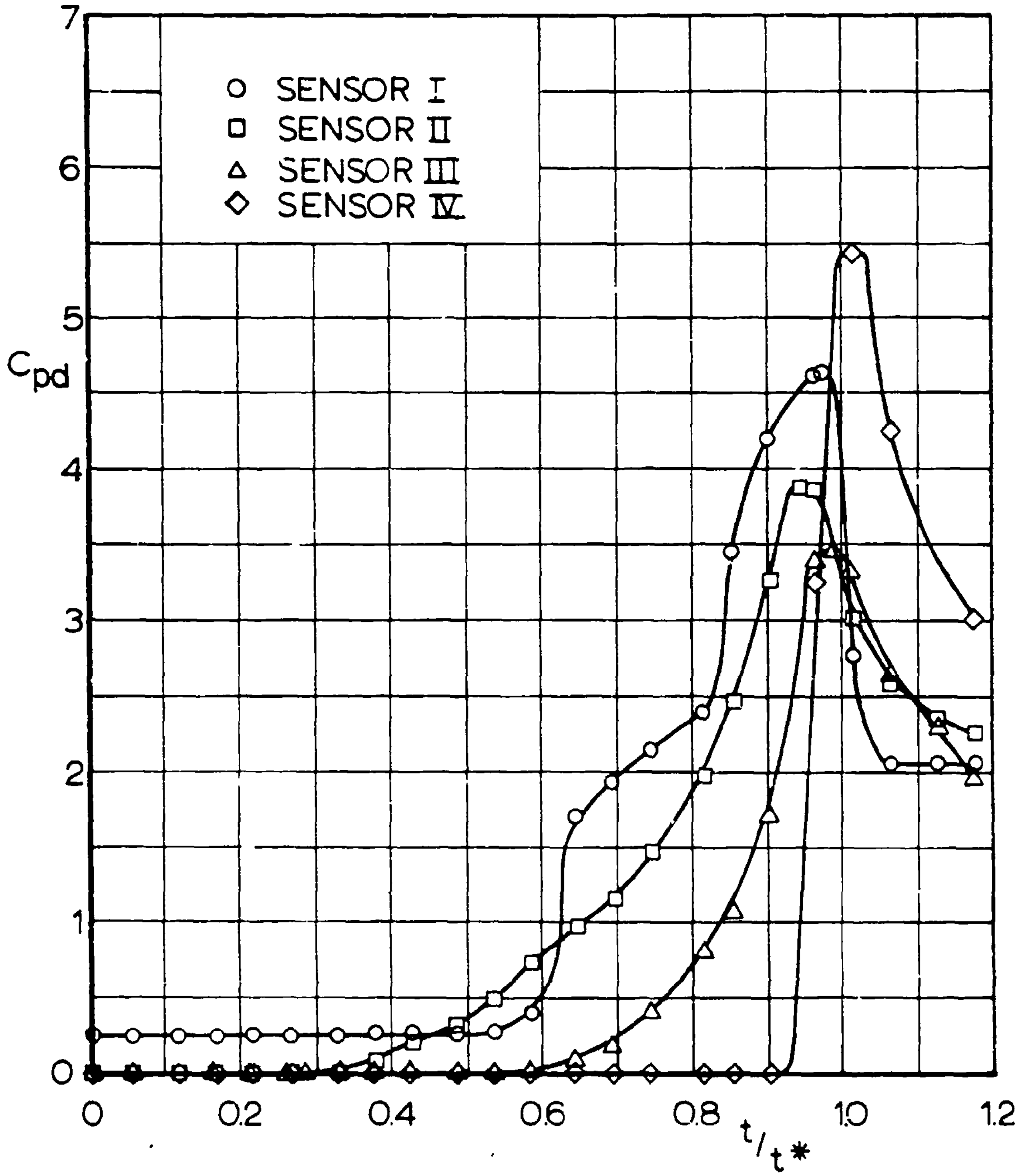


Fig 10 Measured Differential Pressure Coefficient vs Time; Solid Flat Circular Parachute, V_o = 130 ft/sec (Based on Ref 1, Run 187)

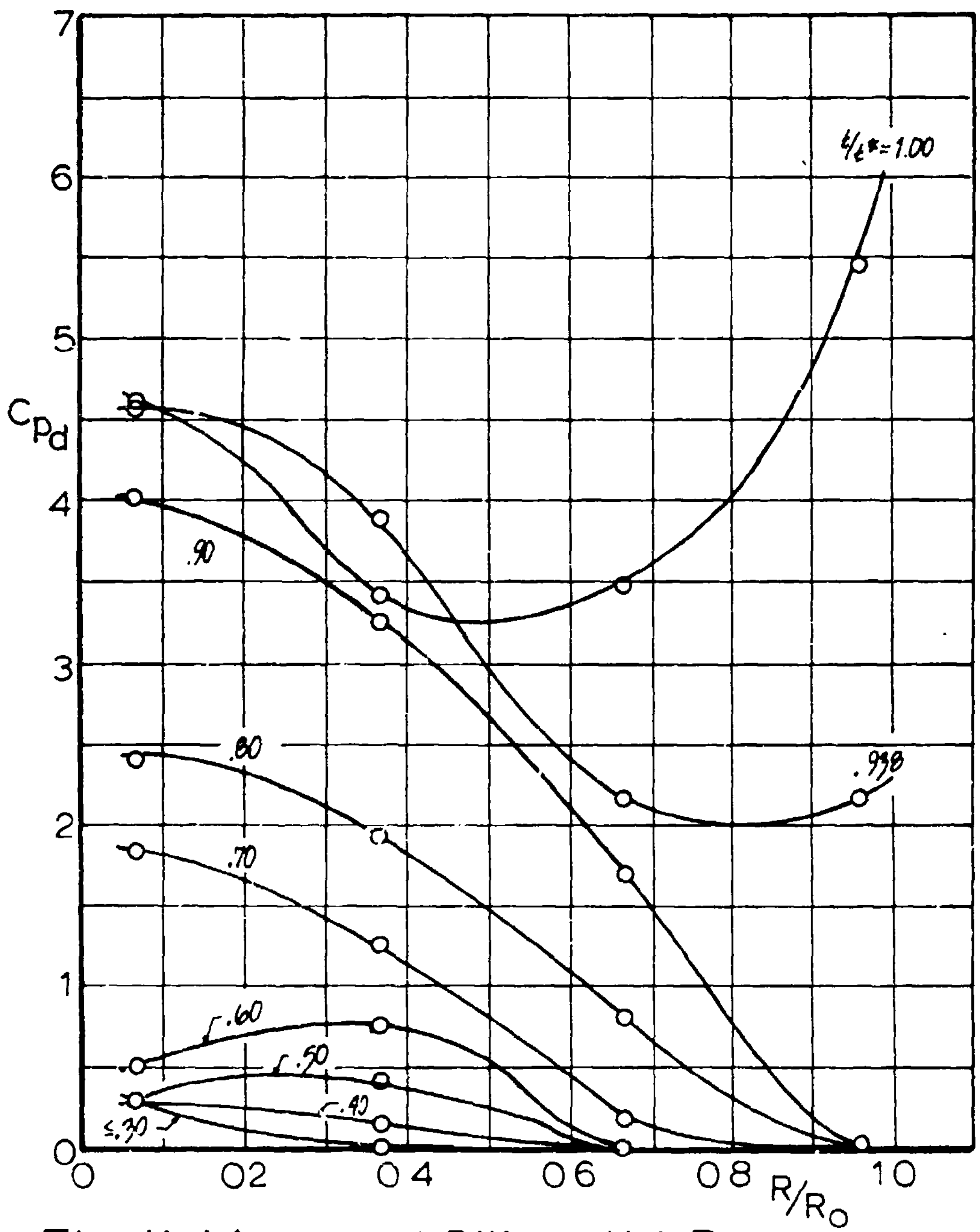


Fig 11 Measured Differential Pressure Coefficient vs Location; Solid Flat Circular Parachute, V_o = 130 ft sec (Based on Ref 1, Run 187)

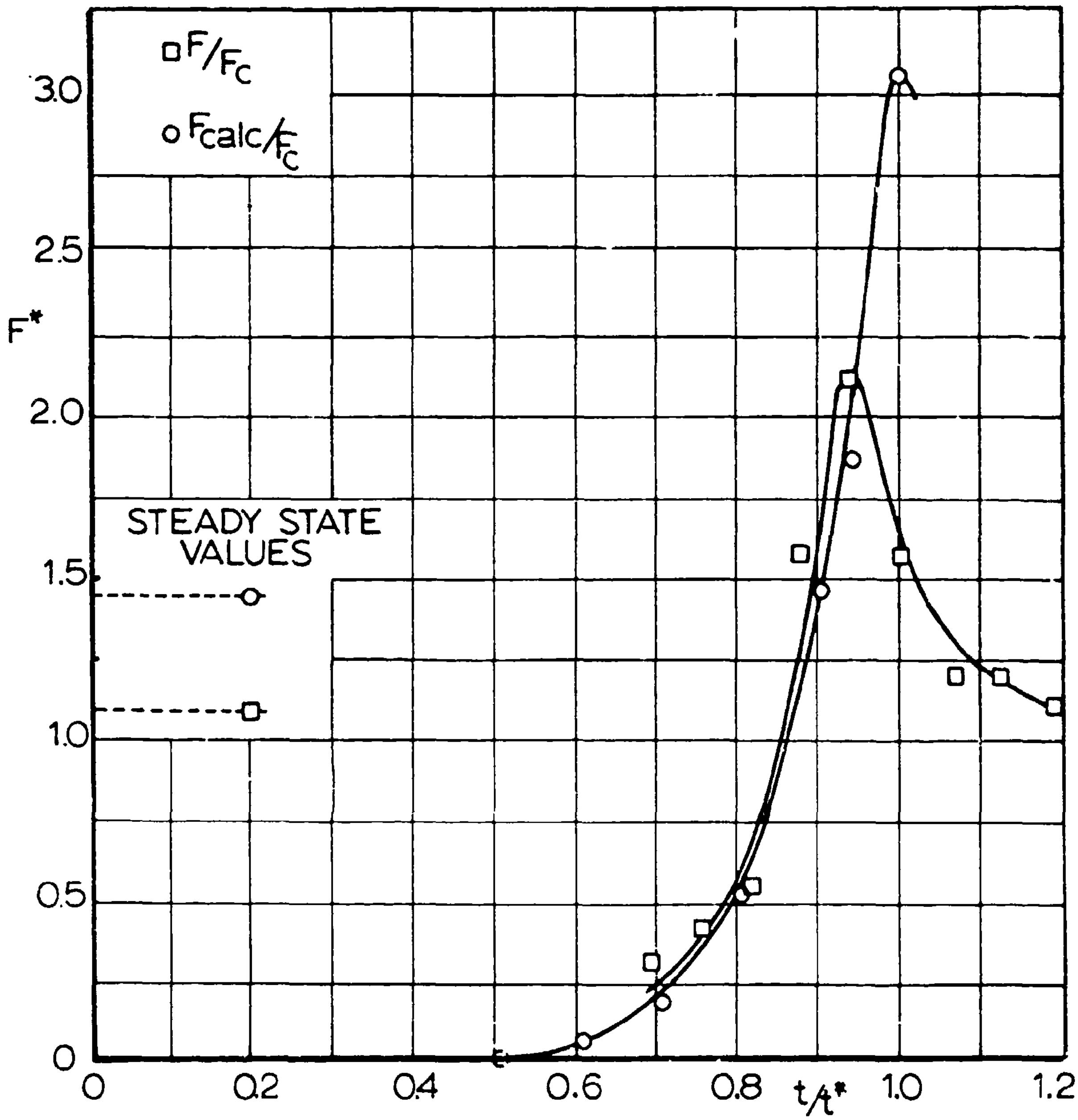


Fig 12 Dimensionless Measured and Calculated Instantaneous Forces; Solid Flat Circular Parachute, $V_O = 130$ ft/sec (Based on Refs 1,2; Run 187)

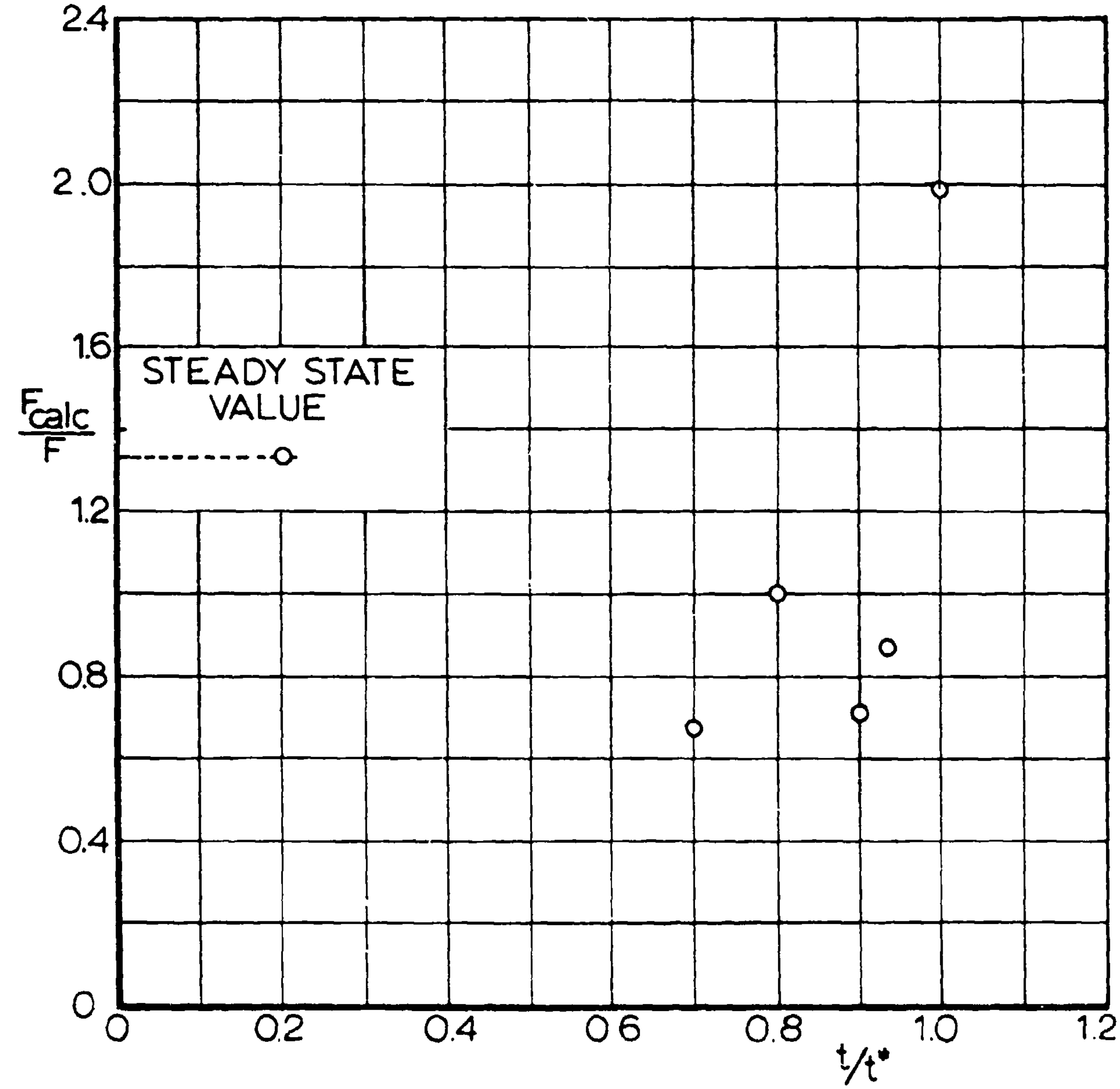


Fig 13 Ratio of Calculated and Measured Instantaneous Forces; Solid Flat Circular Parachute, V_o = 130 ft/sec (Based on Refs 1, 2 ;Run 187)

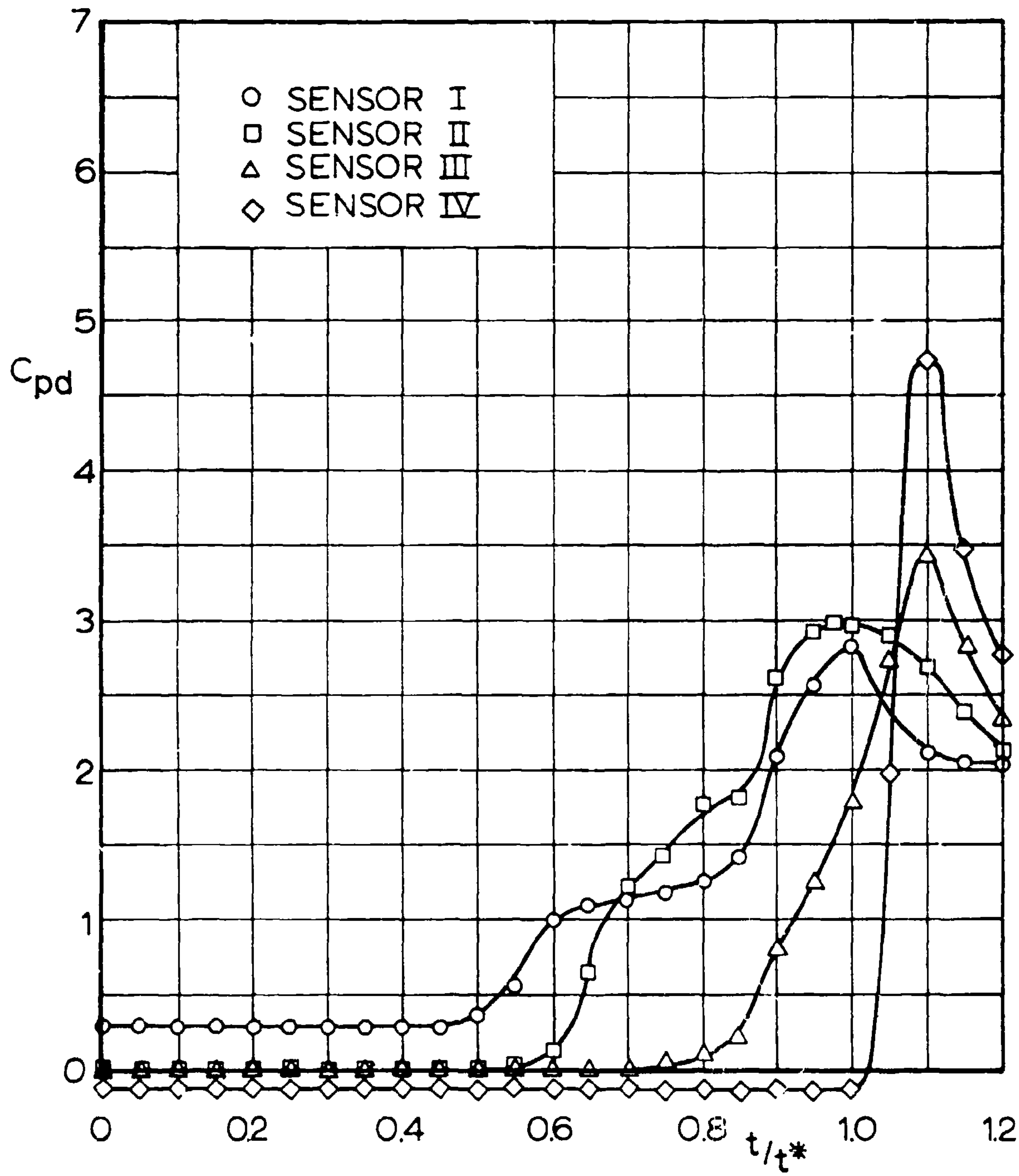


Fig 14 Measured Differential Pressure Coefficient vs Time; Solid Flat Circular Parachute, V_0 = 160 ft/sec (Based on Ref 1, Run 191)

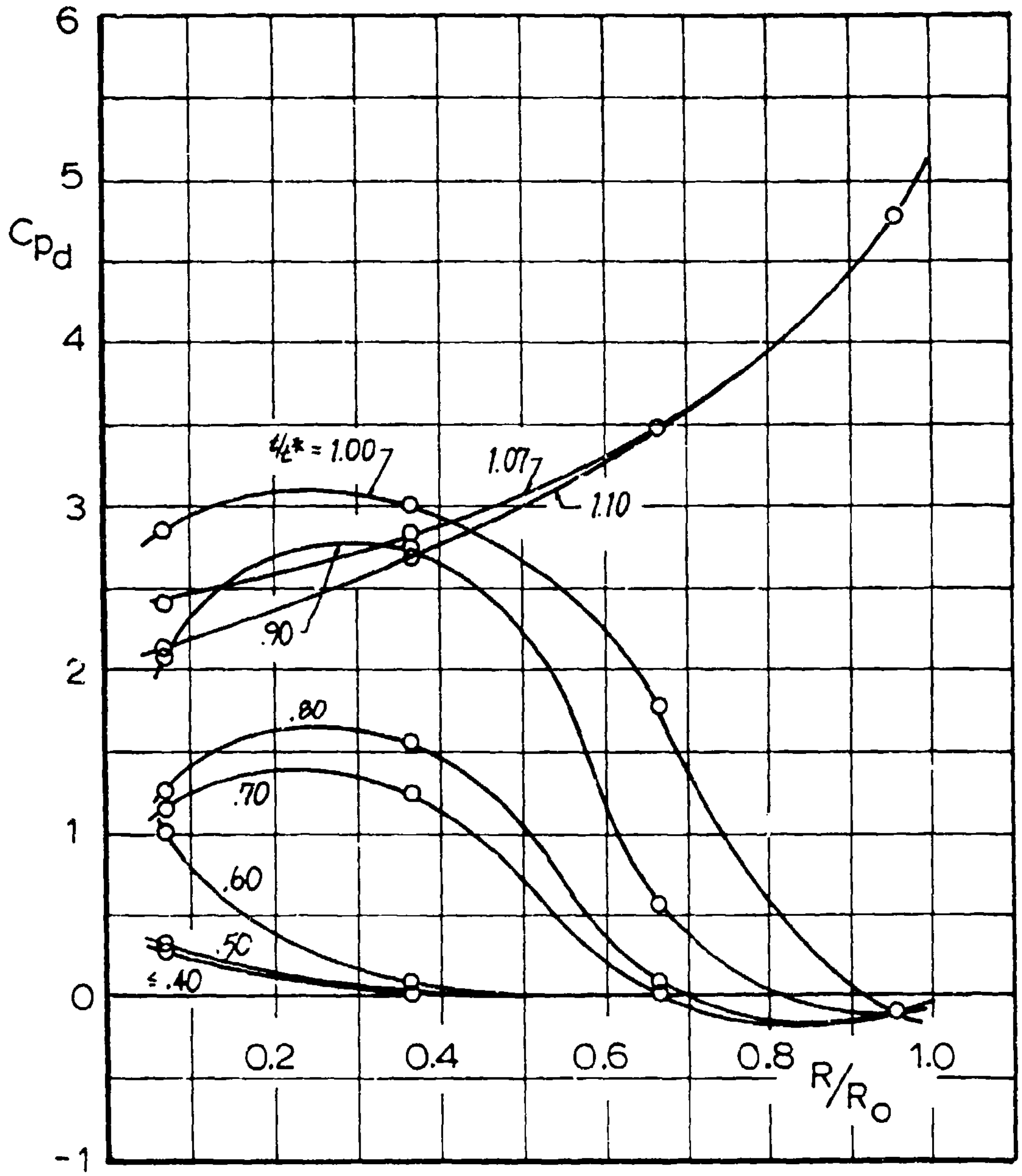


Fig 15 Measured Differential Pressure Coefficient vs Location; Solid Flat Circular Parachute, $V_o = 160$ ft/sec (Based on Ref 1, Run 191)

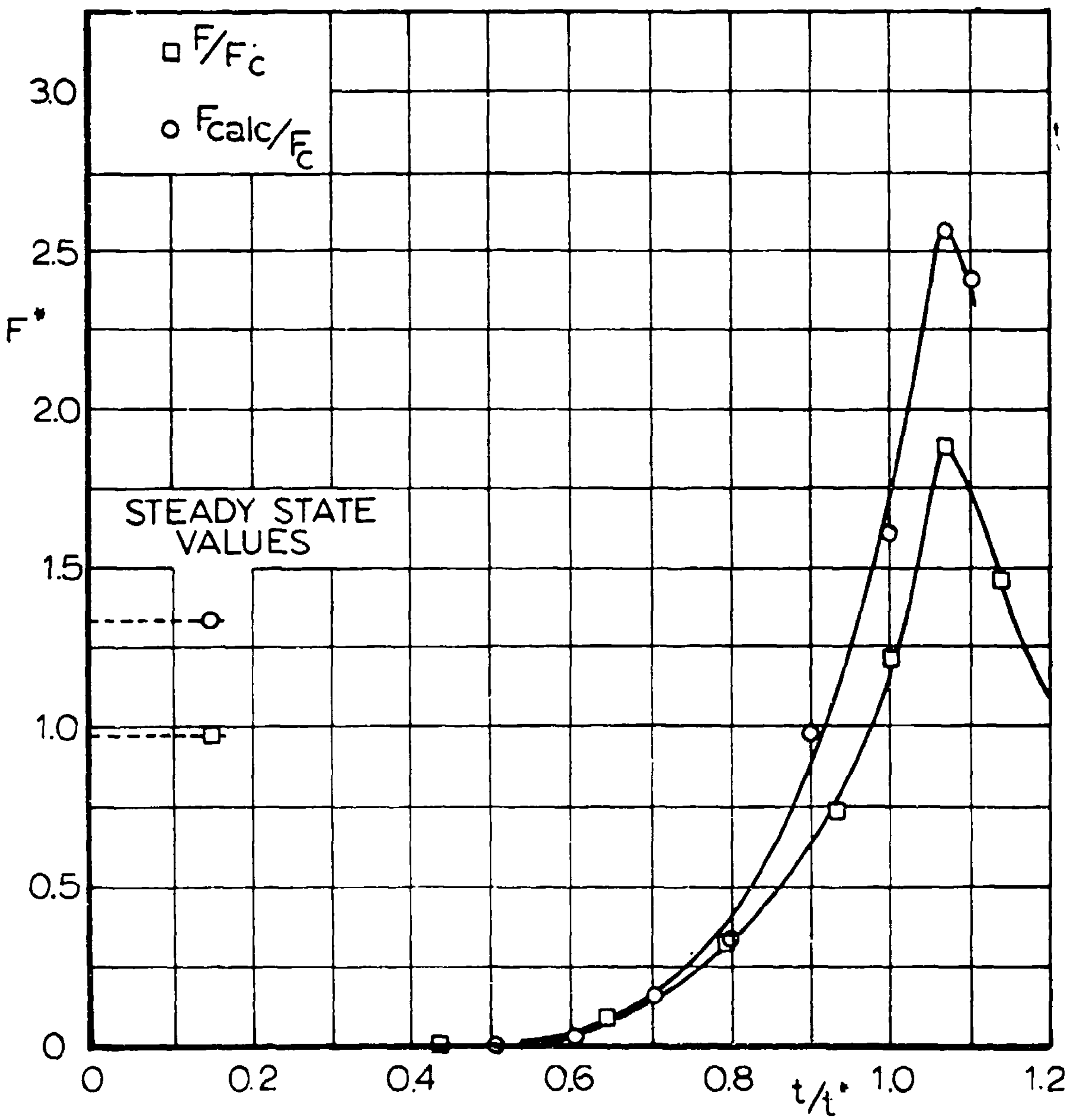


Fig 16 Dimensionless Measured and Calculated Instantaneous Forces; Solid Flat Circular Parachute, V_o = 160 ft/sec (Based on Refs 1,2; Run 191)

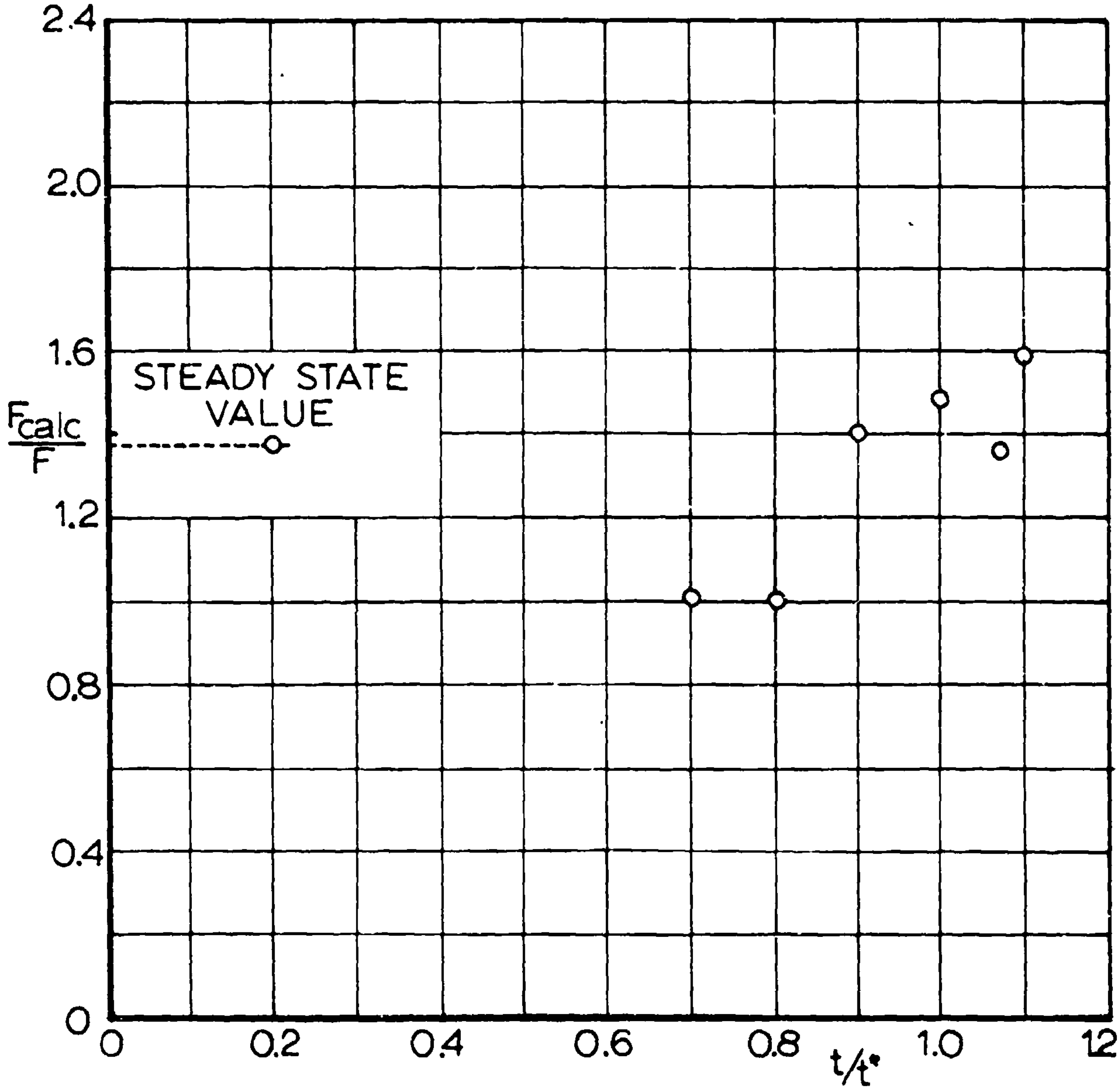


Fig 17 Ratio of Calculated and Measured Instantaneous Forces; Solid Flat Circular Parachute, V_O =160 ft/sec (Based on Refs 1, 2;Run 191)

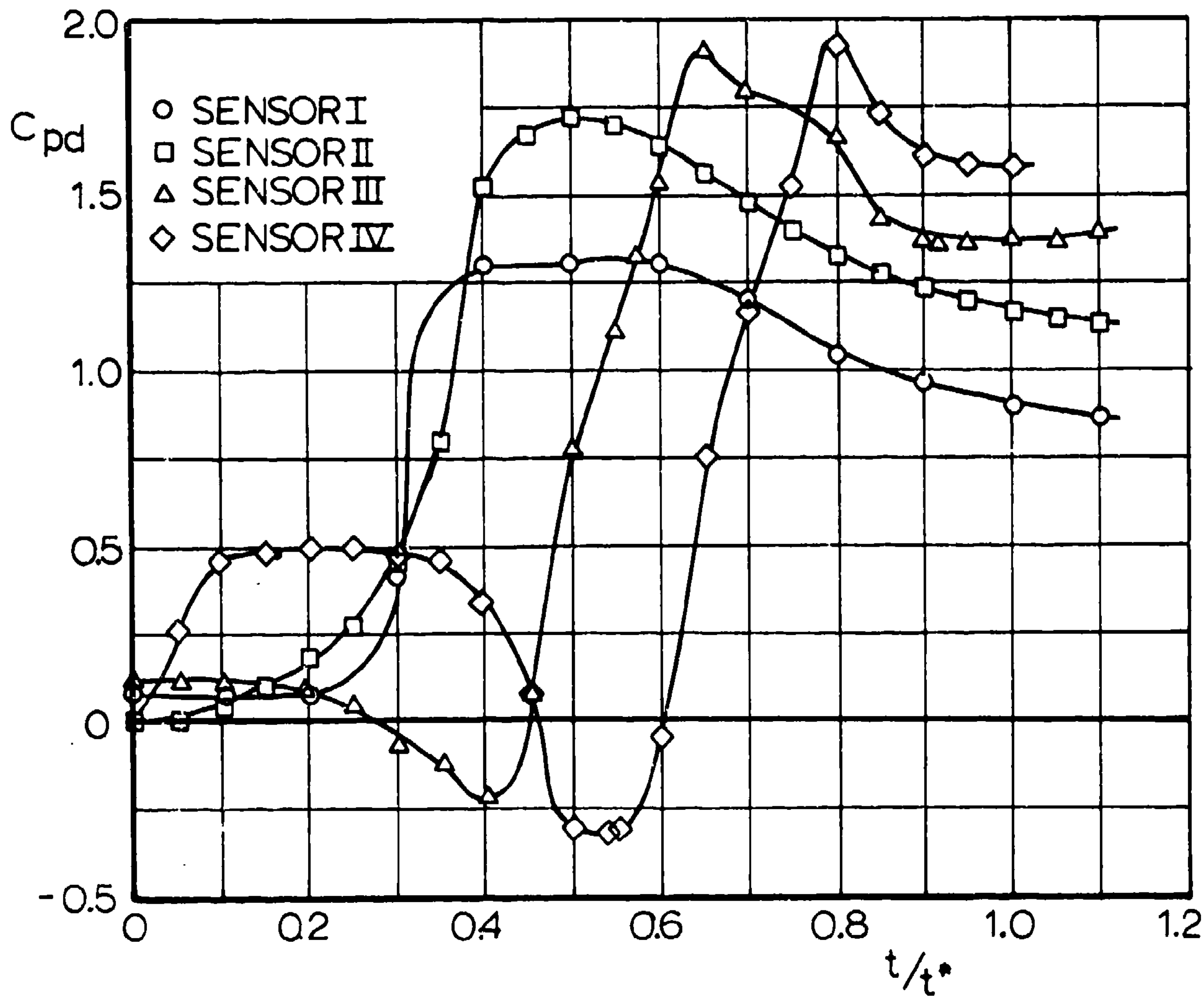


Fig 18 Measured Differential Pressure Coefficient vs Time; Ringslot Parachute, $V_o = 70$ ft/sec (Based on Ref 1, Run 7)

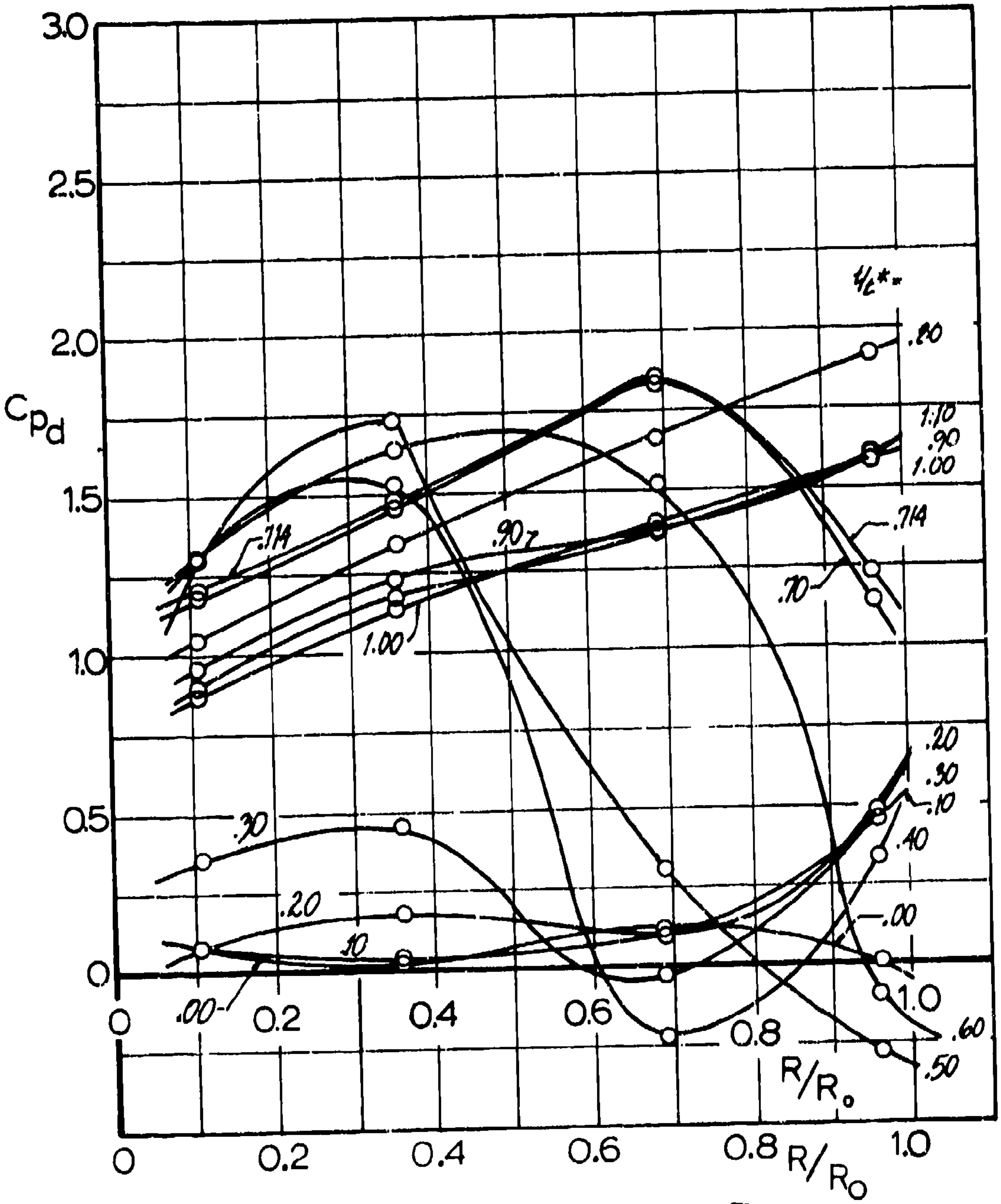


Fig 19 Measured Differential Pressure Coefficient vs Location; Ringslot Parachute, V_o = 70 ft sec (Based on Ref 1, Run 7)

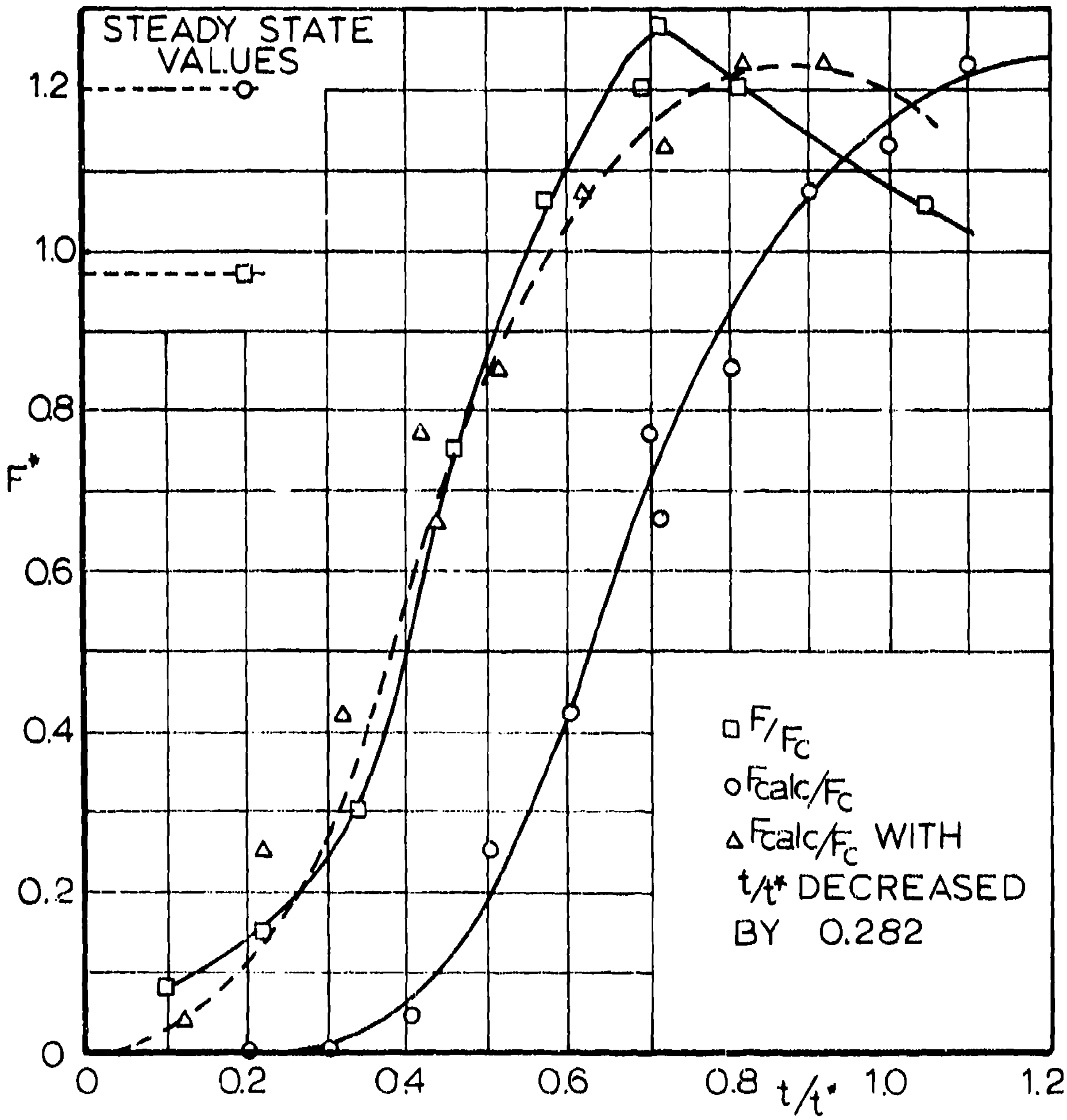


Fig 20 Dimensionless Measured and Calculated Instantaneous Forces; Ringslot Parachute $V_O = 70$ ft/sec
(Based on Refs 1,2; Run 7)

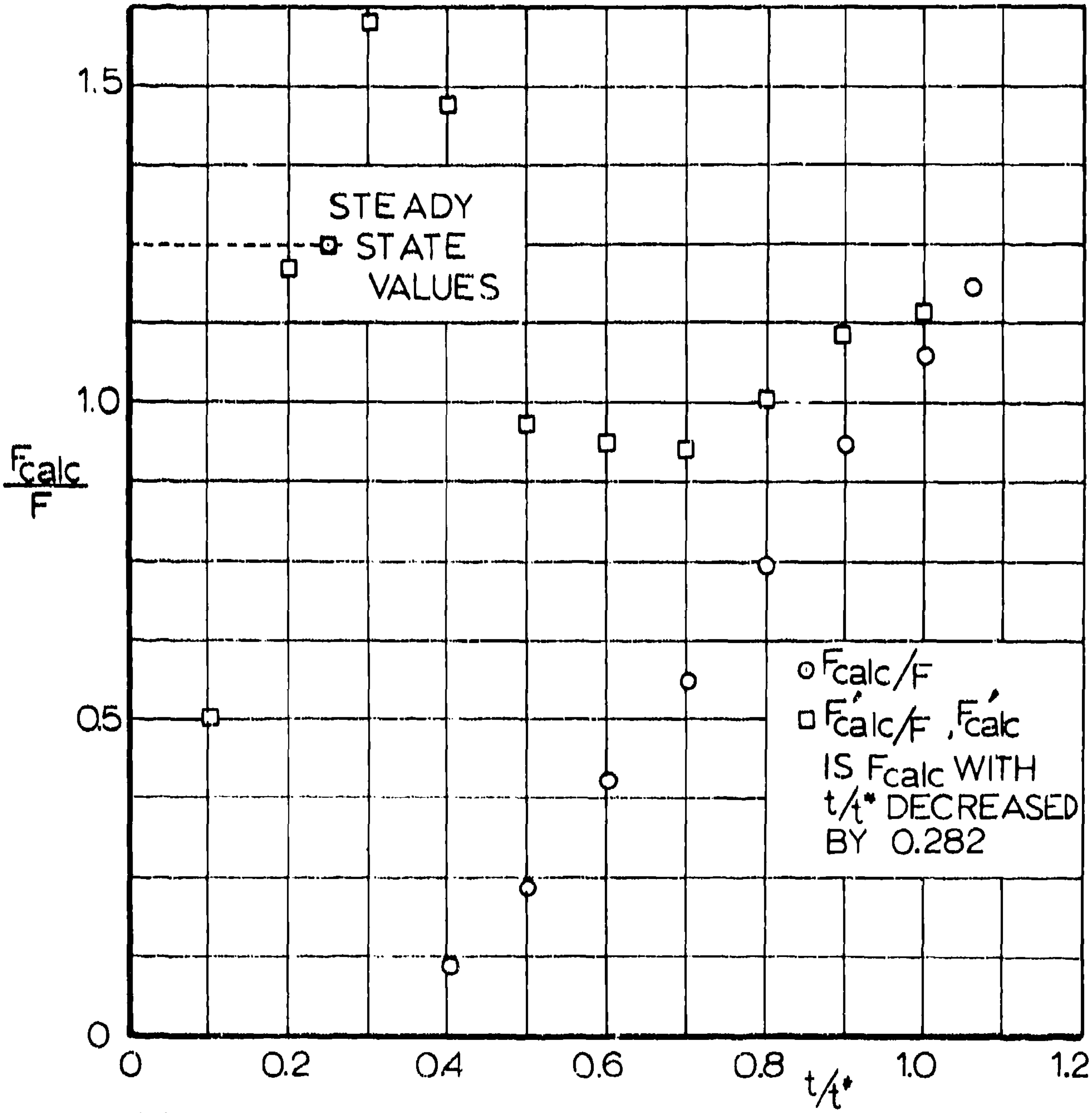


Fig 21 Ratio of Calculated and Measured Instantaneous Forces; Ringslot Parachute V_O = 70 ft/sec
(Based on Refs 1, 2; Run 7)

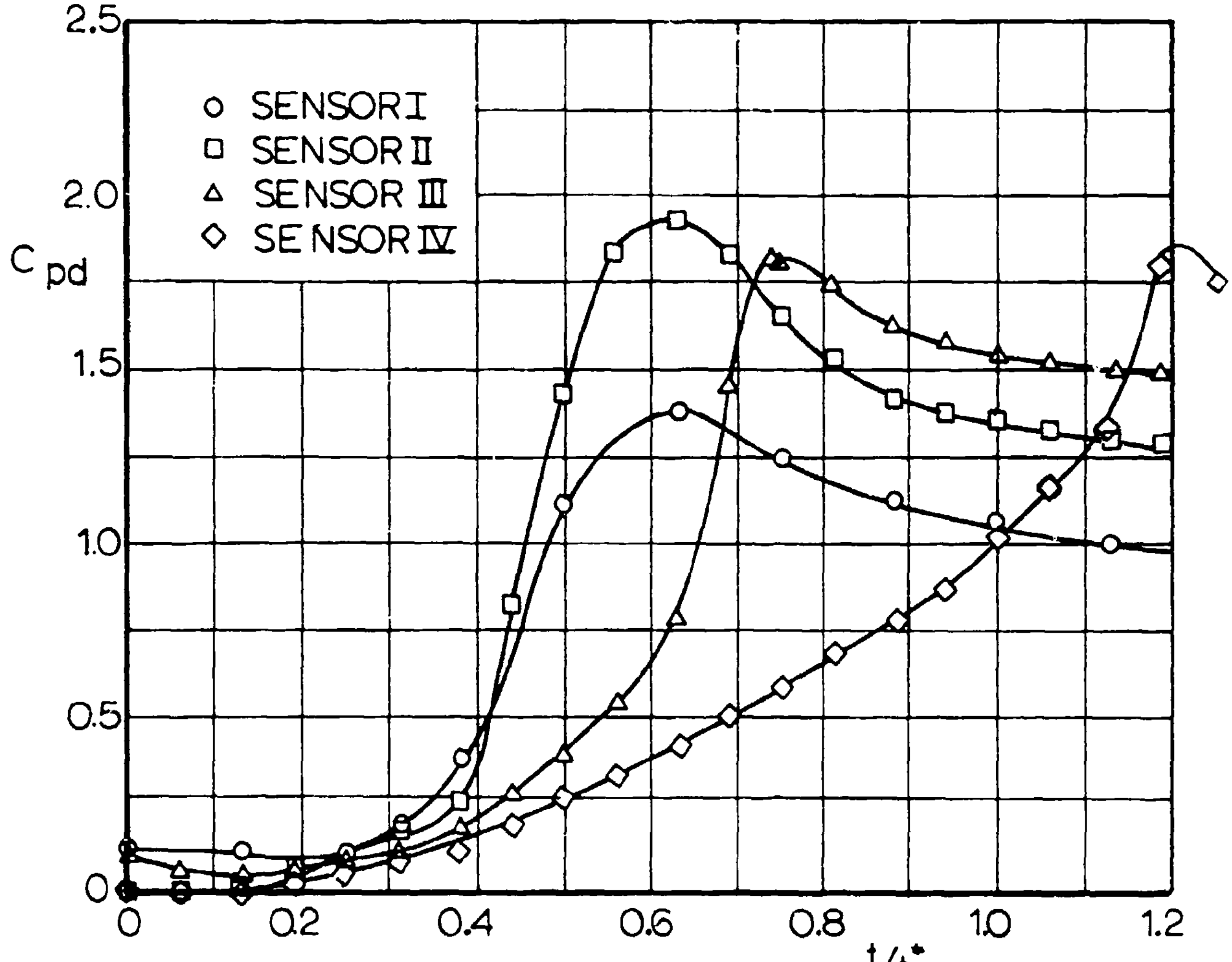


Fig 22 Measured Differential Pressure Coefficient vs Time; Ringslot Parachute V_0 = 100 ft/sec
(Based on Ref 1, Run 10)

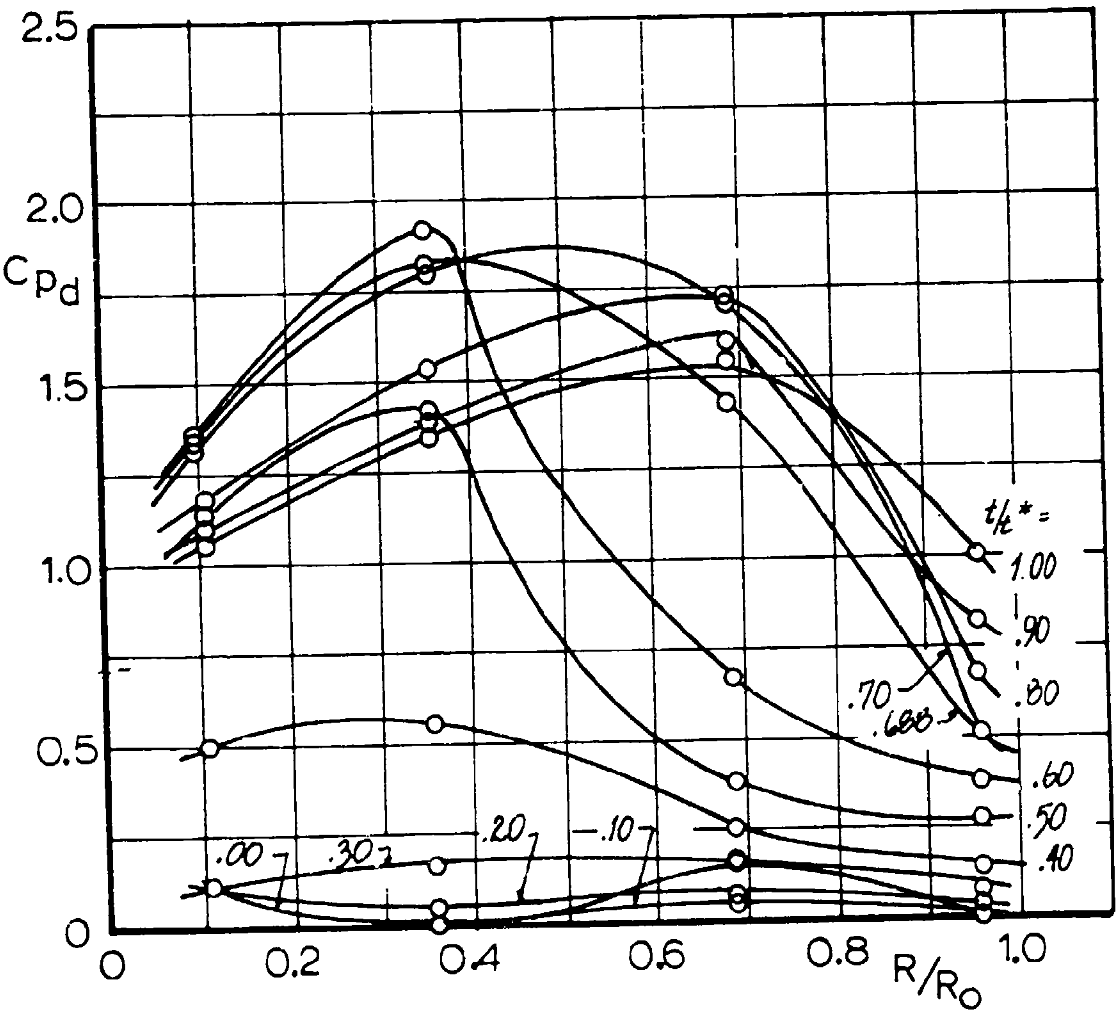


Fig 23 Measured Differential Pressure Coefficient vs Location; Ringslot Parachute, $V_o = 100$ ft/sec (Based on Ref 1, Run 10)

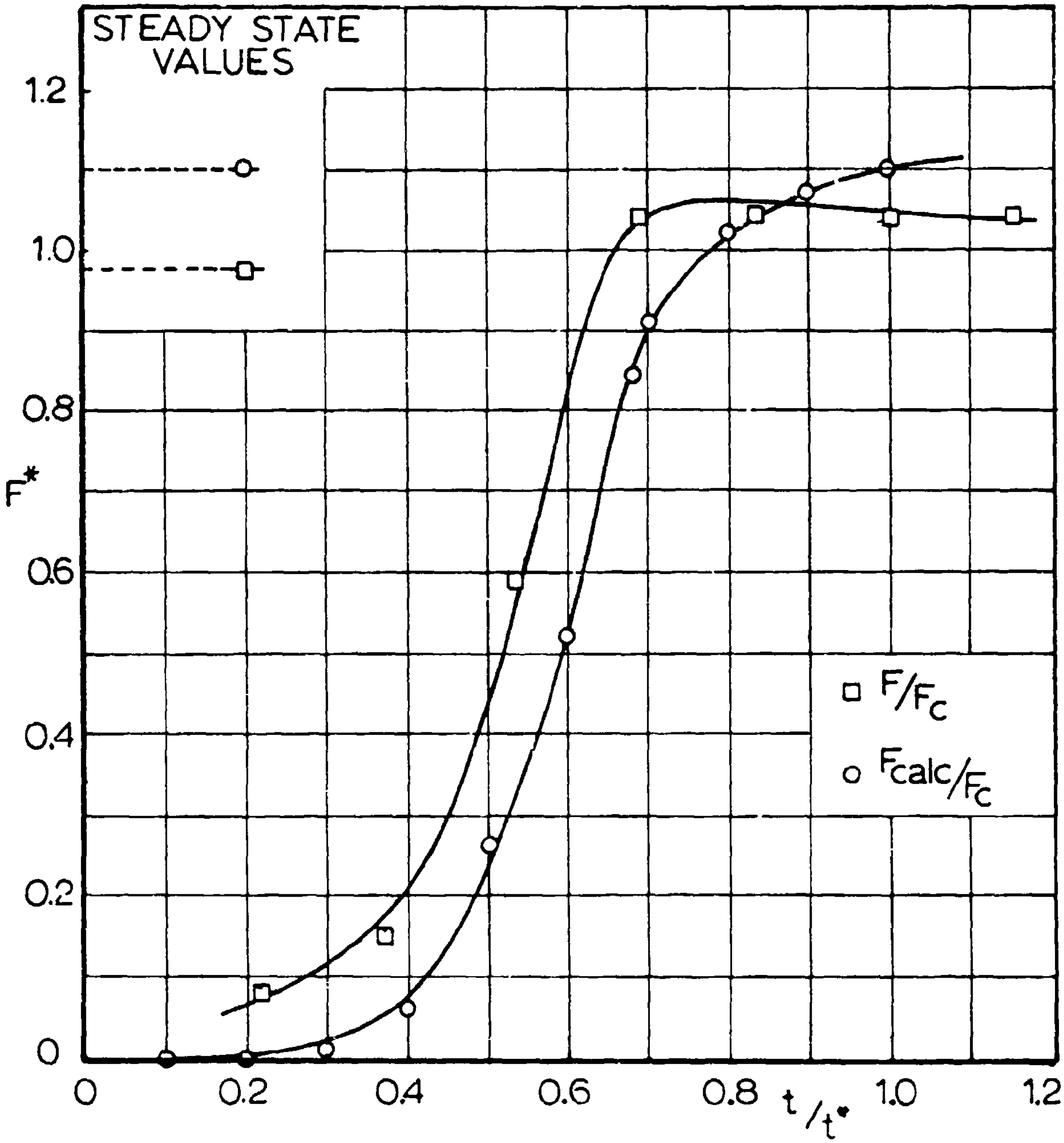


Fig 24 Dimensionless Measured and Calculated Instantaneous Forces; Ringslot Parachute, V_O = 100 ft/sec (Based on Refs 1,2; Run 10)

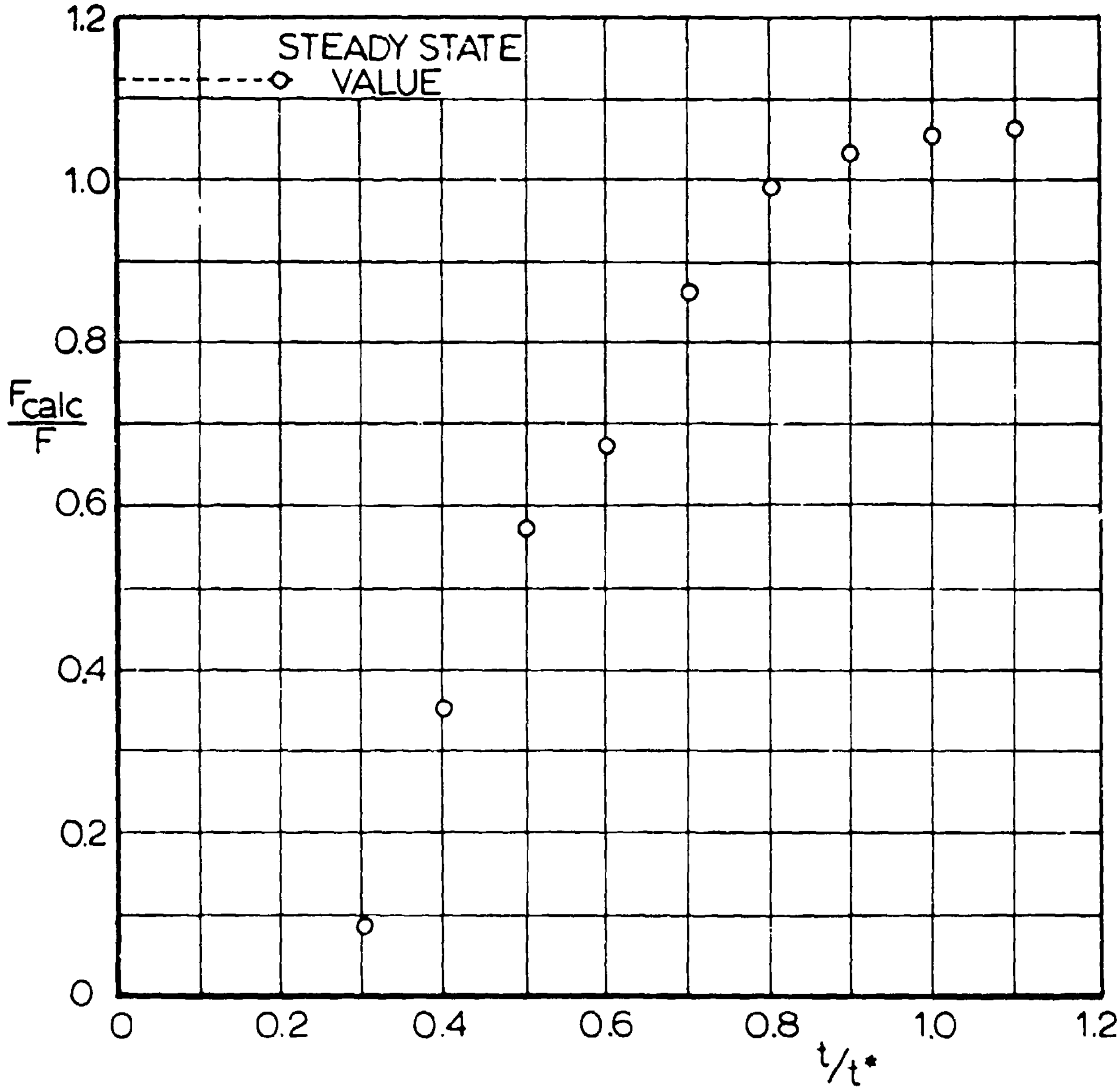


Fig 25 Ratio of Calculated and Measured Instantaneous Forces; Ringslot Parachute V_O = 100 ft/sec (Based on Refs 1, 2; Run 10)

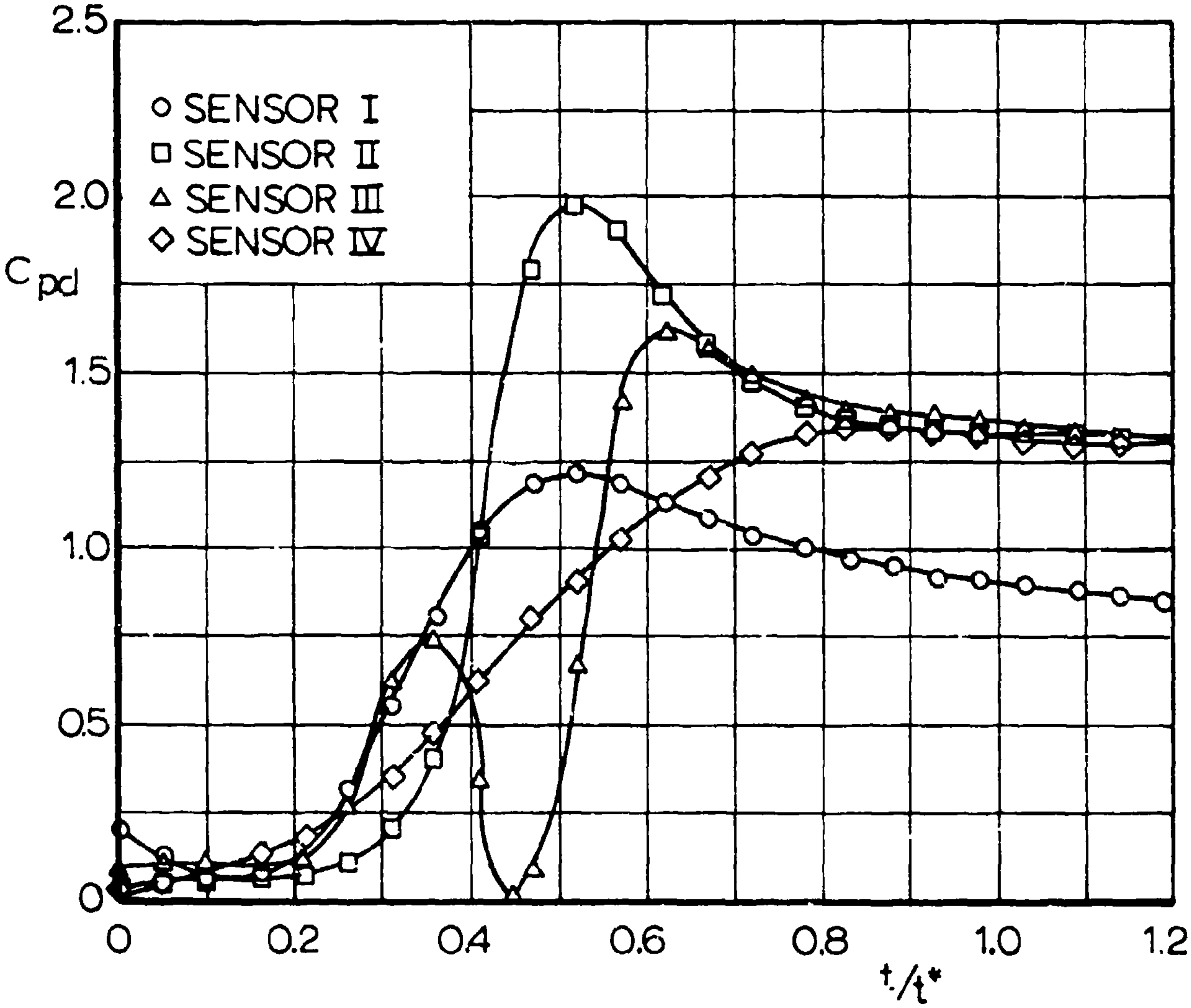


Fig 26 Measured Differential Pressure Coefficient vs Time; Ringslot Parachute V_o =130 ft/sec (Based on Ref 1, Run 14)

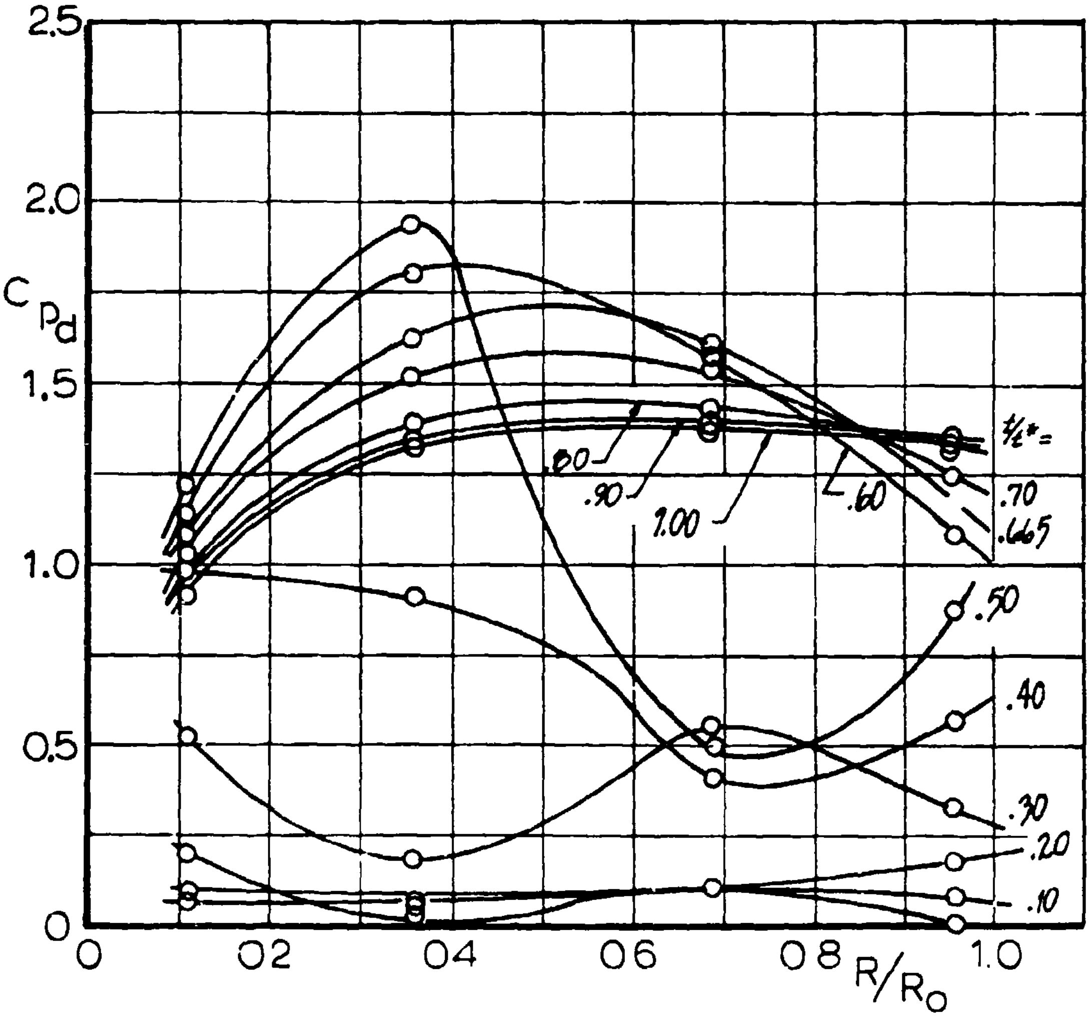


Fig 27 Measured Differential Pressure Coefficient vs Location; Ringslot Parachute, V_o = 130 ft/sec (Based on Ref 1, Run 14)

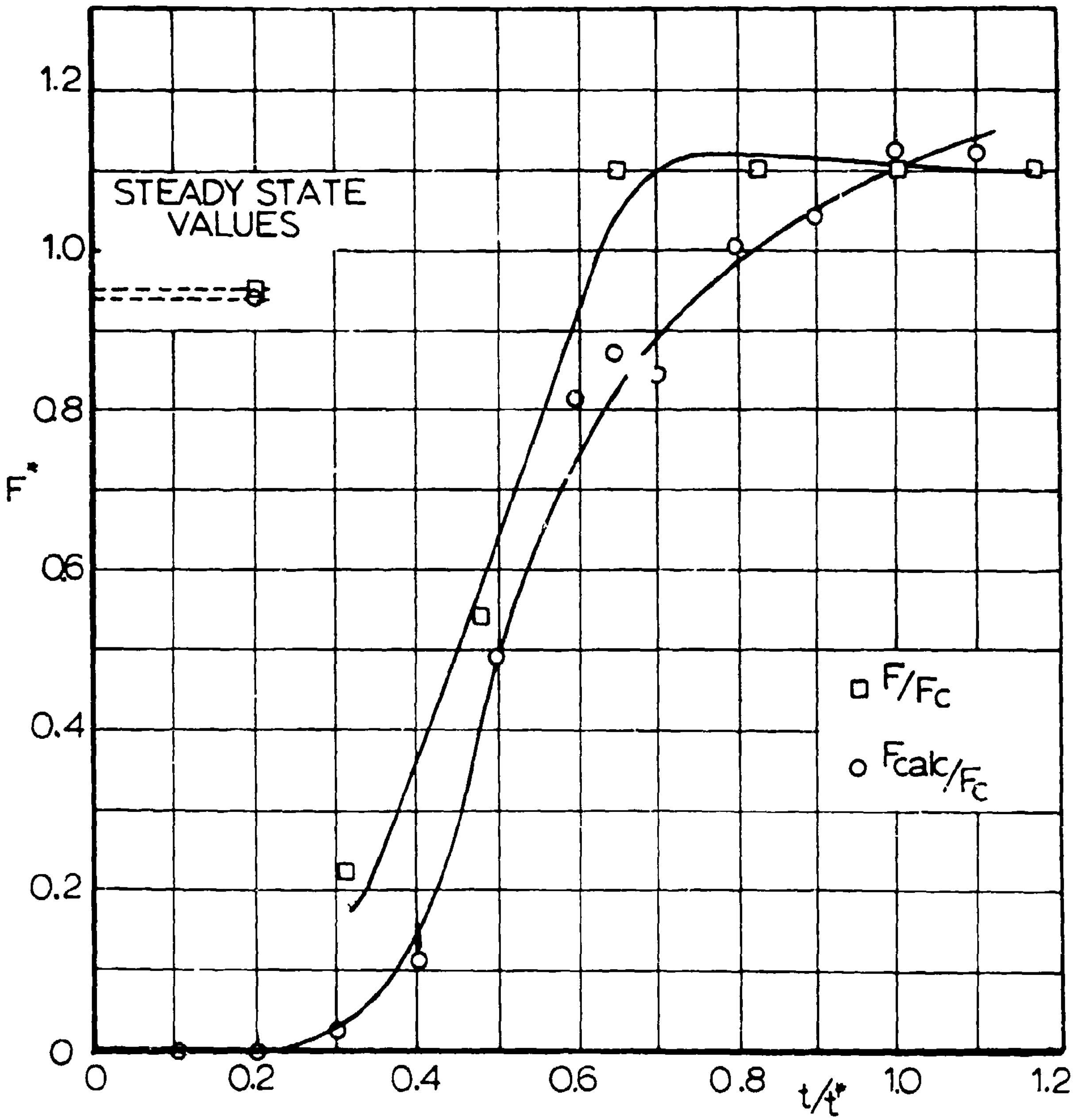


Fig 28 Dimensionless Measured and Calculated Instantaneous Forces; Ringslot Parachute, V_0 =130 ft/sec (Based on Refs 1,2; Run 14)

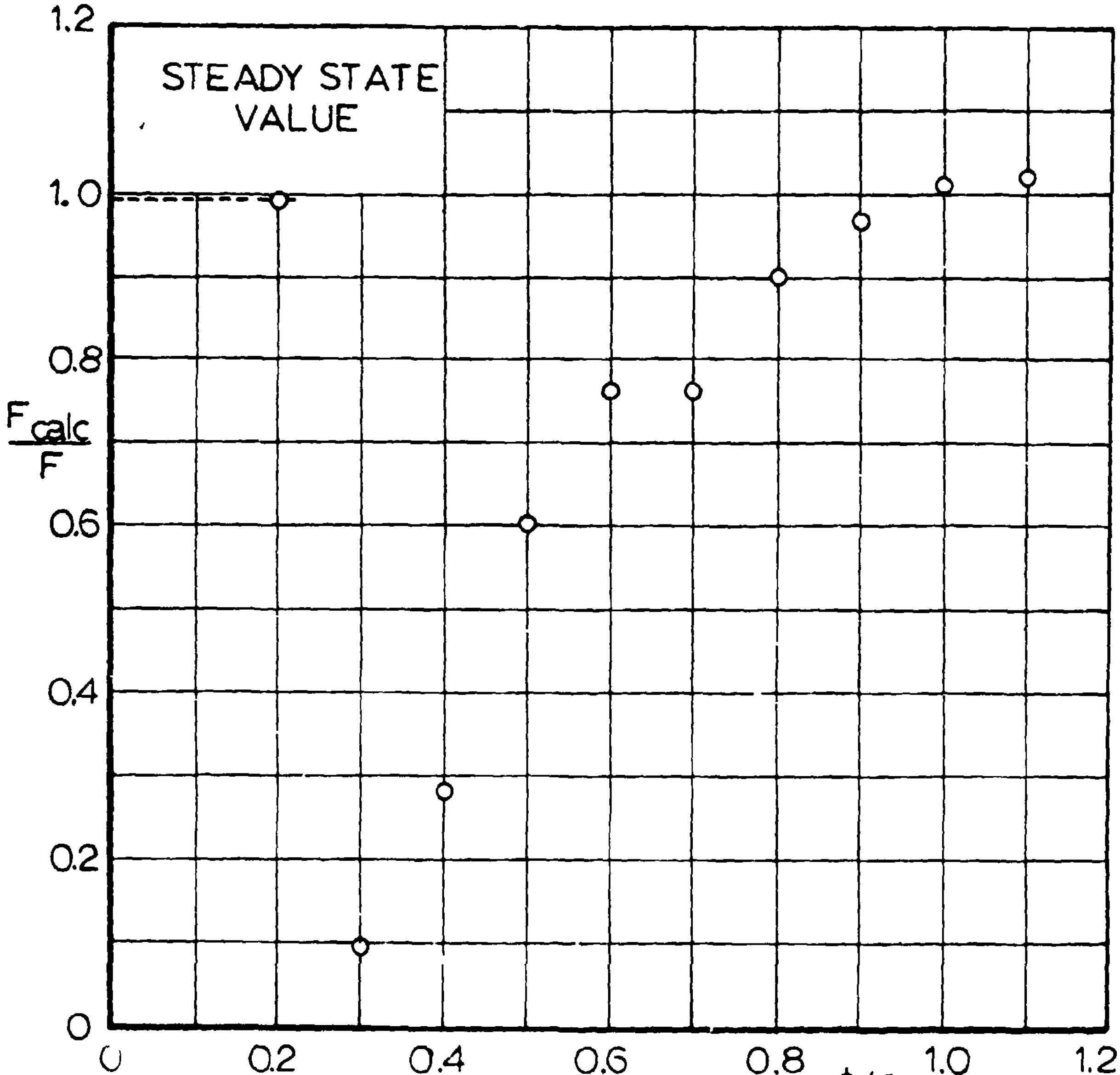


Fig 29 Ratio of Calculated and Measured Instantaneous Forces; Ringslot Parachute V_O = 130 ft/sec (Based on Refs 1, 2; Run 14)

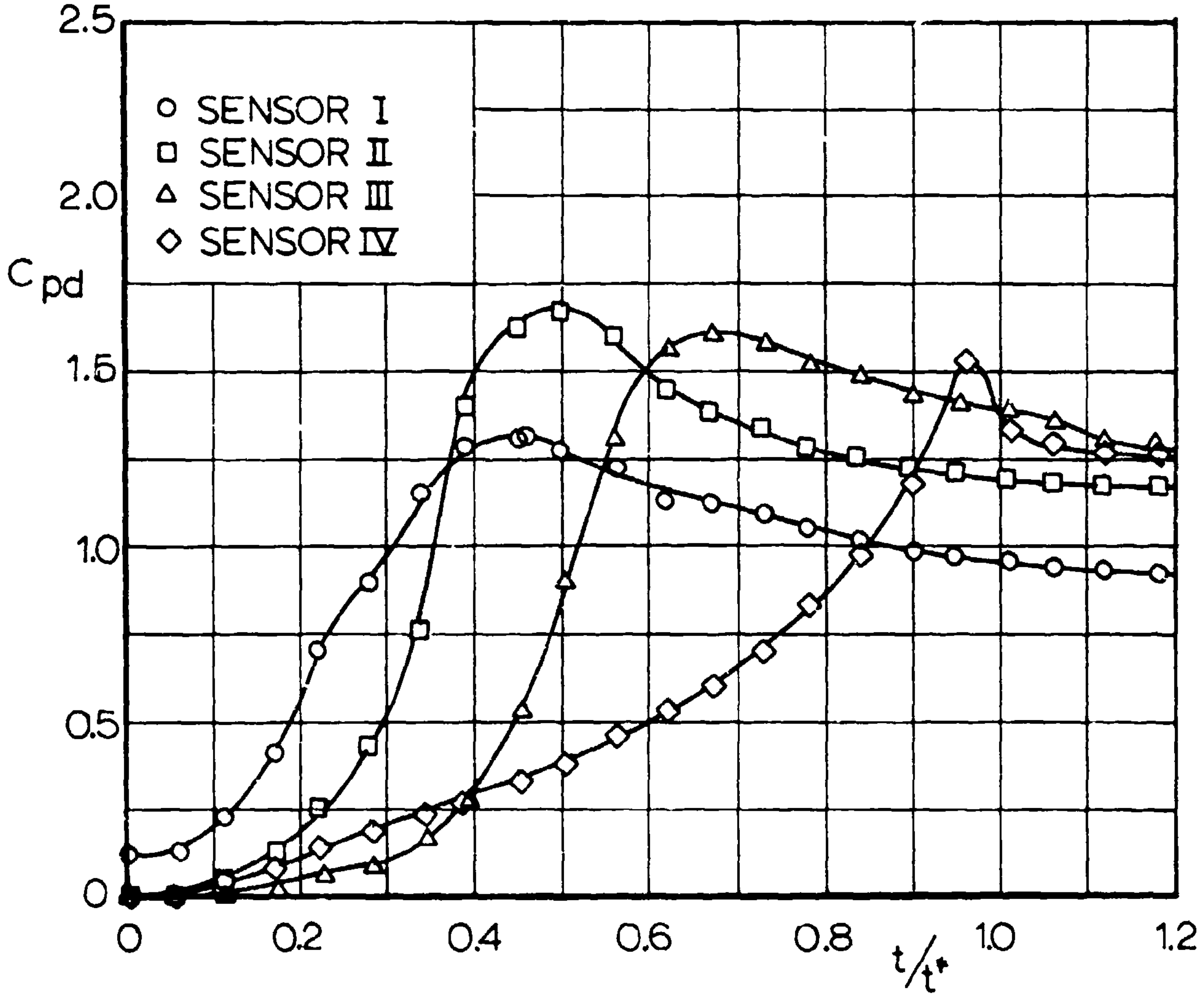


Fig 30 Measured Differential Pressure Coefficient vs Time; Ringslot Parachute V_O = 160 ft/sec (Based on Ref 1 ,Run 18)

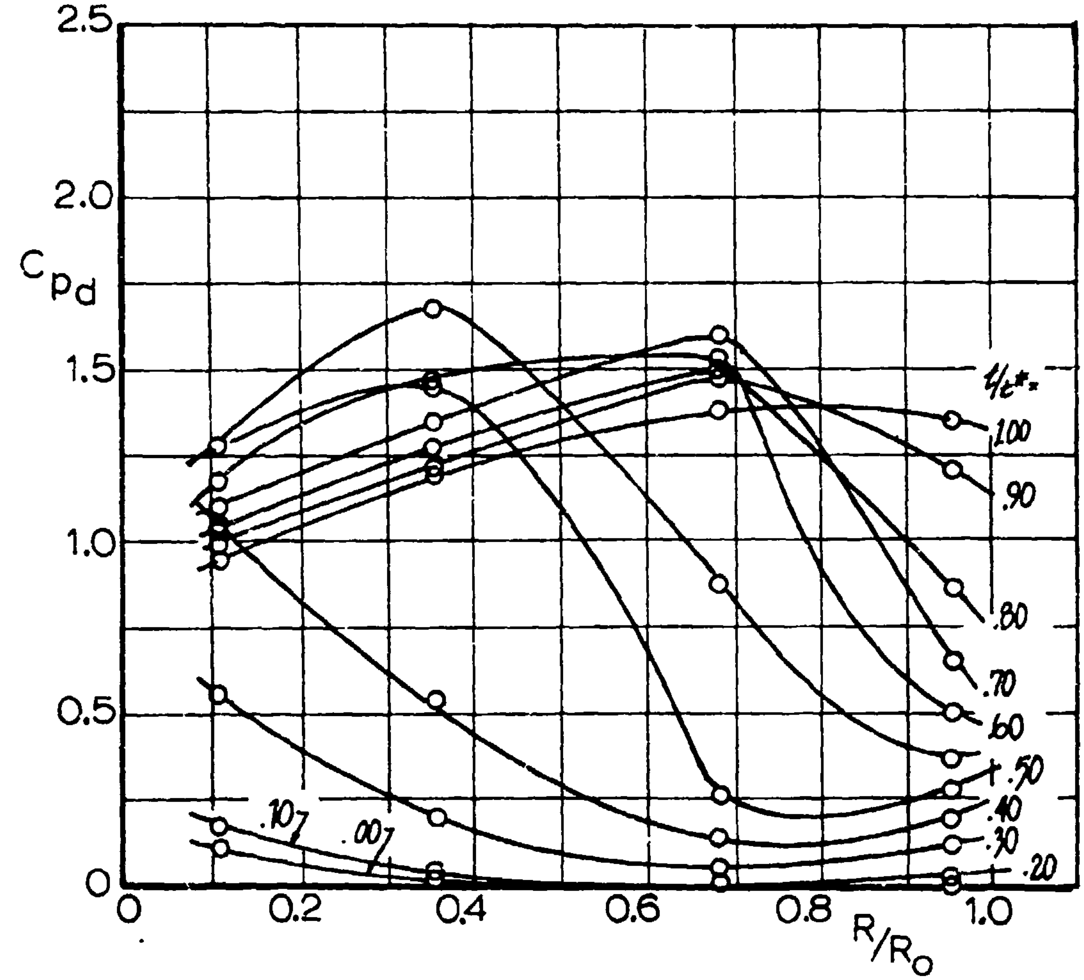


Fig 31 Measured Differential Pressure Coefficient vs Location; Ringslot Parachute, V_O = 160 ft sec (Based on Ref 1, Run 18)

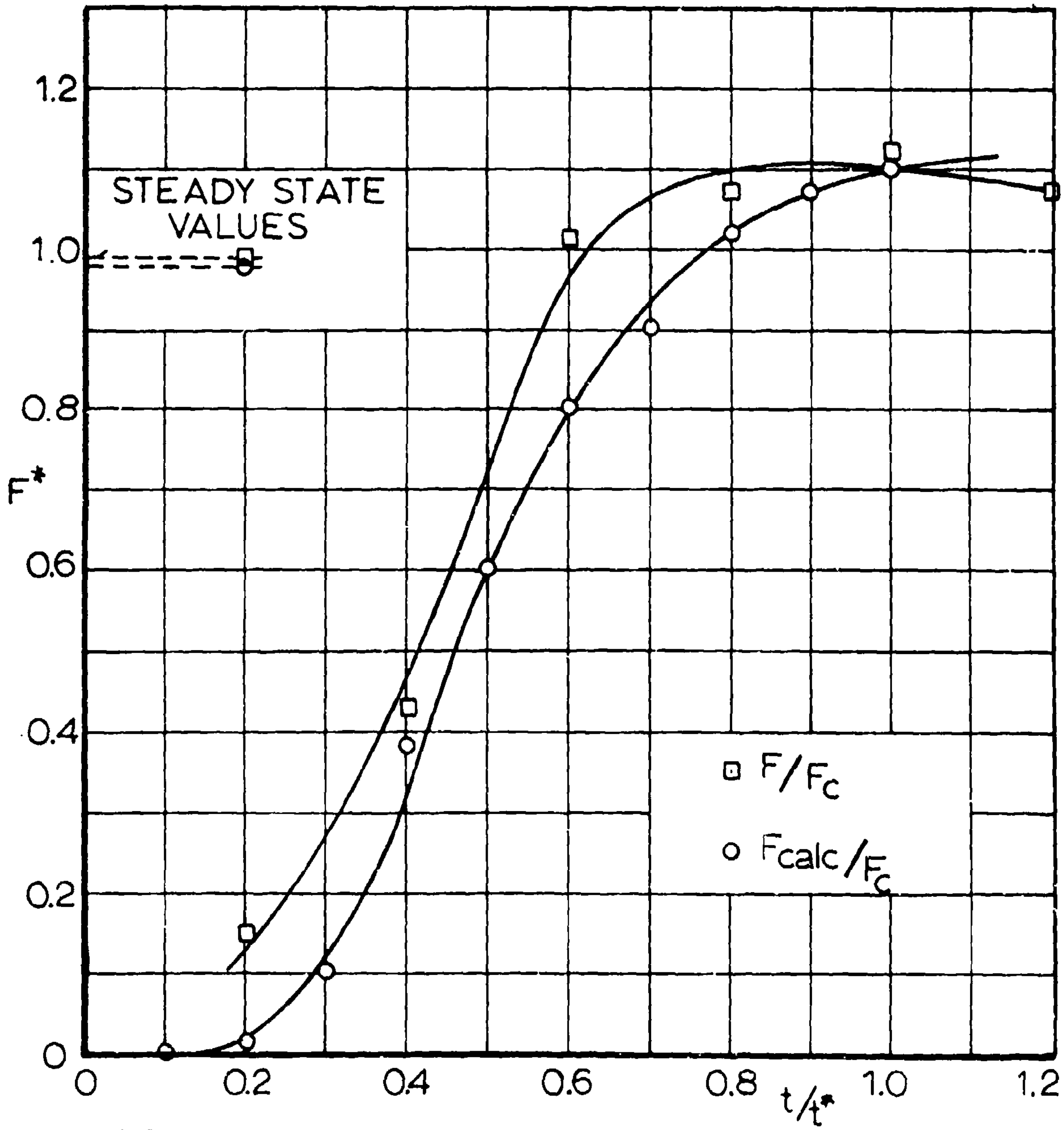


Fig 32 Dimensionless Measured and Calculated Instantaneous Forces; Ringslot Parachute, V_o = 160 ft/sec (Based on Refs 1,2; Run 18)

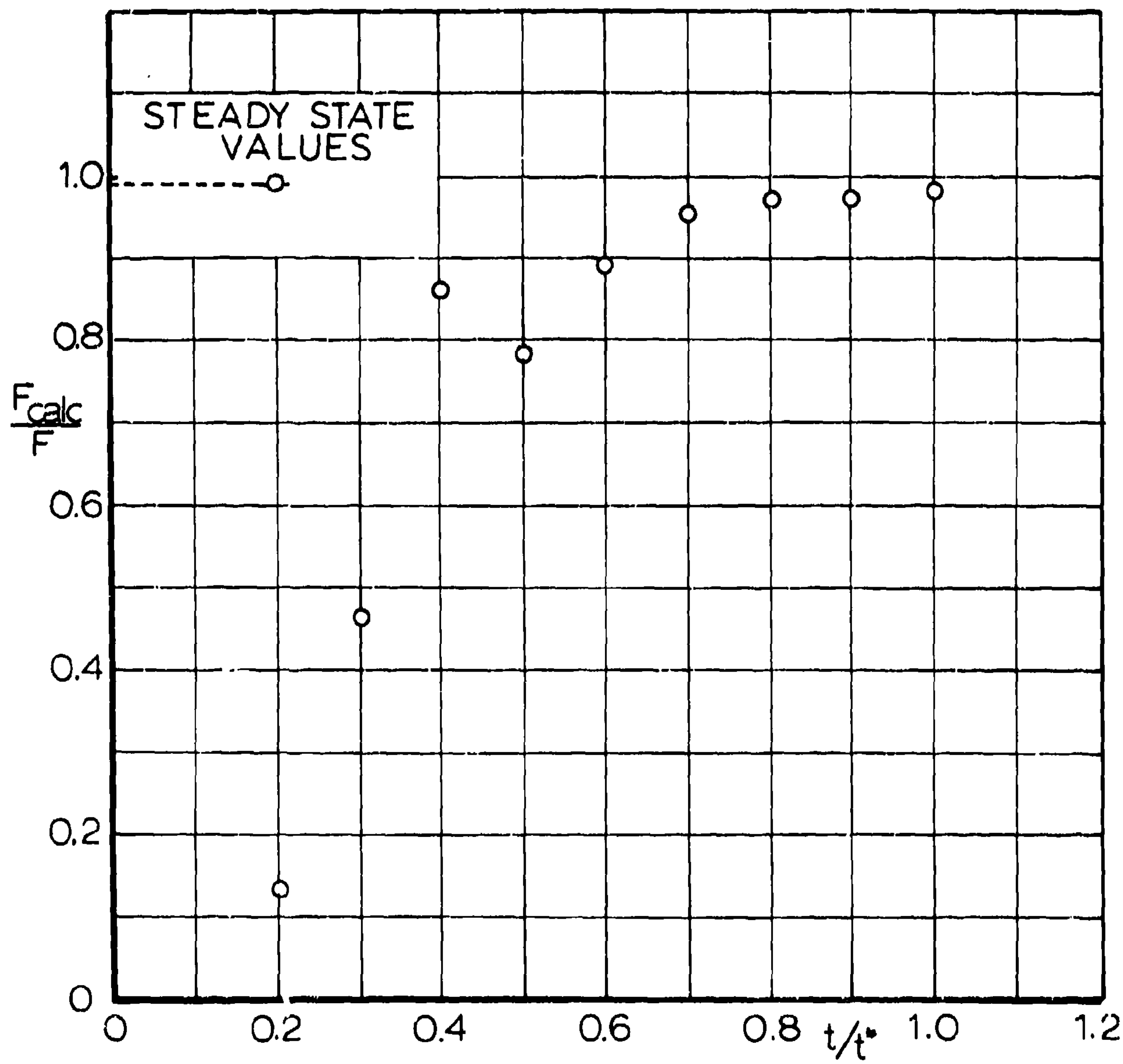


Fig 33 Ratio of Calculated and Measured Instantaneous Force; Ringslot Parachute V_o = 160 ft/sec
(Based on Refs 1, 2; Run 18)

For the examination of all pressure data shown in Ref 1, Tables II to XXXIII in the Appendix, Section II, were established. An analysis of these tables shows the following situation.

In the tests of the solid flat parachute, it was noted that at the 130 fps velocity at all four locations the pressure coefficients generally increased more quickly with respect to T_o than at other freestream velocities, whereas the velocity had no noticeable effect on the magnitude of peak pressure coefficients or the time at which the maximum pressure occurred. The ringslot tests showed that the 160 fps velocity caused the earliest rise of pressure. Again the values of the peak pressures and their time of occurrence did not seem to depend on velocity. The tap locations nearest the skirt showed great fluctuation in pressure with time, especially the external coefficients. In general, however, the pressure-time curves followed approximately the same trend for all velocities.

Disregarding these deviations it was assumed that as an approximation a unique pressure-time curve, which is velocity independent, could be extracted for each of the four pressure transducer locations.

In the pursuit of this objective, the difference between the internal and external pressure coefficients measured at the four points and at various velocities was compared with the measured differential pressure coefficient measured at the same points and identical conditions. This showed that, for the same time instant and velocity, the quantity $(C_{p_i} - C_{p_e})$ differed from the reported value of C_{p_d} considerably. For example, near the maximum pressures these differences varied between 2% and 4,000% of C_{p_d}, whereby C_{p_d} is larger as well as smaller than $(C_{p_i} - C_{p_e})$. A typical example of this discrepancy is shown in Fig 34, and it was decided that the pressure coefficients could not be averaged with respect to time T_o.

Another way of checking the validity of reported C_p coefficients is to compare their peak values at various velocities regardless of time of occurrence. Therefore, the quantity $(C_{p_i} - C_{p_e})$ was compared with the measured C_{p_d} value obtained at a given velocity on the same tap location. The differences between $(C_{p_i} - C_{p_e})$ and C_{p_d} varied from 0.5%

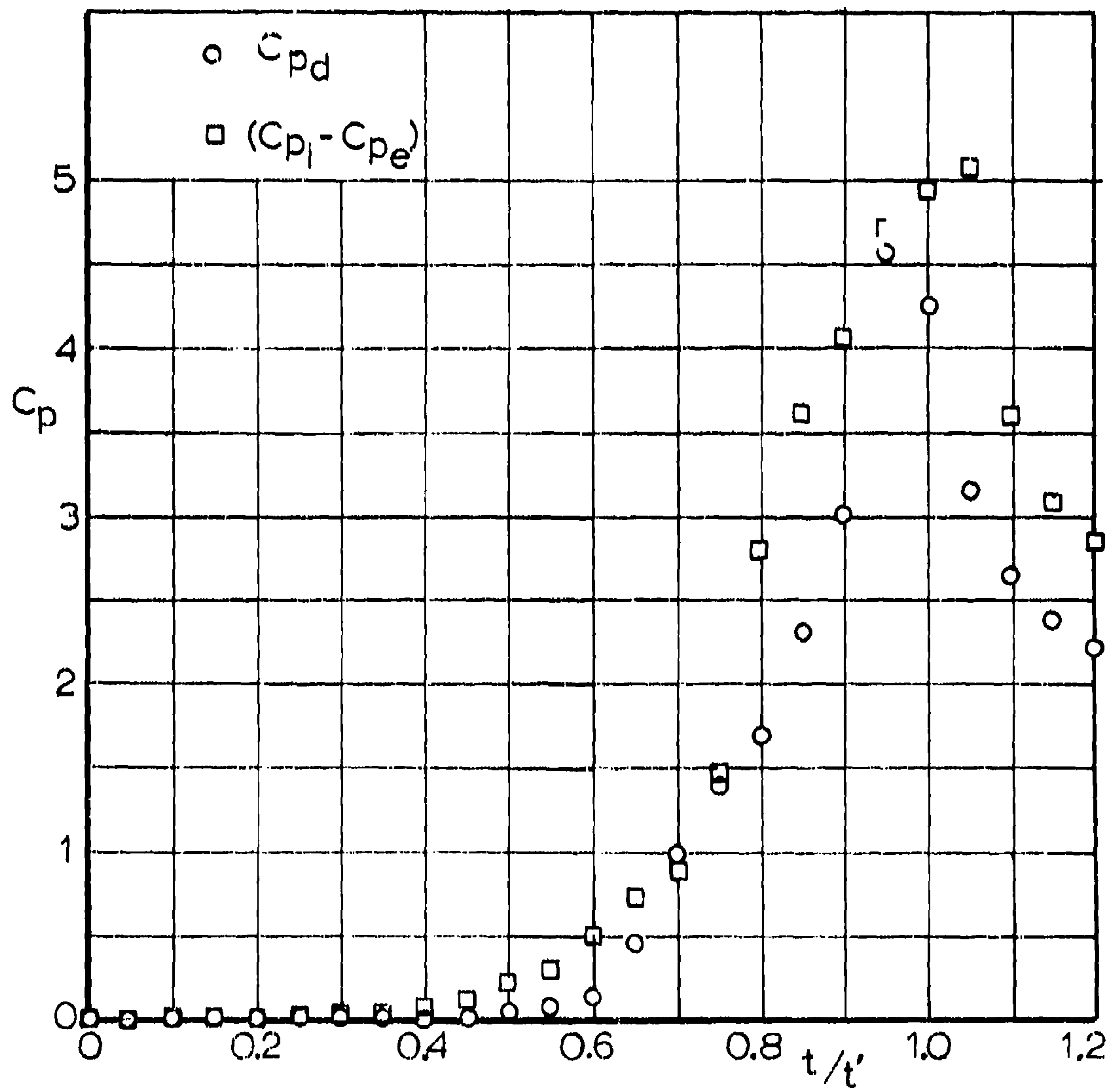


Fig 34 Comparison Between C_{p_d} and $(C_{p_i} - C_{p_e})$ for Solid Flat Circular Parachute, Sensor II, V = 100 ft/sec (Based on Ref 1, Runs 183, 200, 216)

to 35.3% of the reported C_{p_d}, and up to 65% for the solid flat and ringslot parachute, respectively. No indications could be found which measurements are more realistic. Therefore, it was decided to utilize both the measured pressure coefficient C_{p_d} and the calculated differential coefficient $C_{p_i} - C_{p_e}$. Details of how average differential pressures were established are described in the following.

Summarizing all operations which seemed to be necessary to fit all data of Refs 1 and 2 into the scheme of this study, the following steps were taken.

1. All pressure data used for further evaluation were rearranged with respect to T_o. Details of this process are shown in Tables II-XXXIII, Section III, of the Appendix.

2. The pressure-time relationship, obtained as described above, could not be simply averaged because the C_{p_e}, C_{p_i}, and C_{p_d}-values were obtained from different runs in which the characteristic points corresponding to maximum and steady-state pressures occurred at different times, T_o. Therefore, characteristic pressure and time values corresponding to the instances of $T_o = 0$, $dC_p/dT_o > 0$, $dC_p/dT_o = 0$ and $C_{p_{max}}$, and C_p = const. were established. This process is shown in Fig 35a. The pressure values and their times, T_o, were averaged. From the averaged values new or replacement curves of C_{p_e} and C_{p_i} vs T_o were obtained, Fig 35b. The curvature between the time-pressure points was drawn to judgment.

3. The replacement curves $\overline{C_{p_e}}$ and $\overline{C_{p_i}}$ vs $\overline{T_o}$ were combined to differential pressure-time values, called $\overline{C_{p_d}}$ vs $\overline{T_o}$. Corresponding to the scheme shown in Figs 35a and b, the measured values of differential pressure C_{p_d} were obtained from Ref 1. These were put into a similar averaging process and $\overline{C_{p_{d,measured}}}$ vs $\overline{T_o}$ values were established.

4. The averaged values of calculated and measured differential pressures, obtained as explained above, were then combined to new average values called $\overline{\overline{C_{p_d}}}$ vs $\overline{\overline{T_o}}$. These

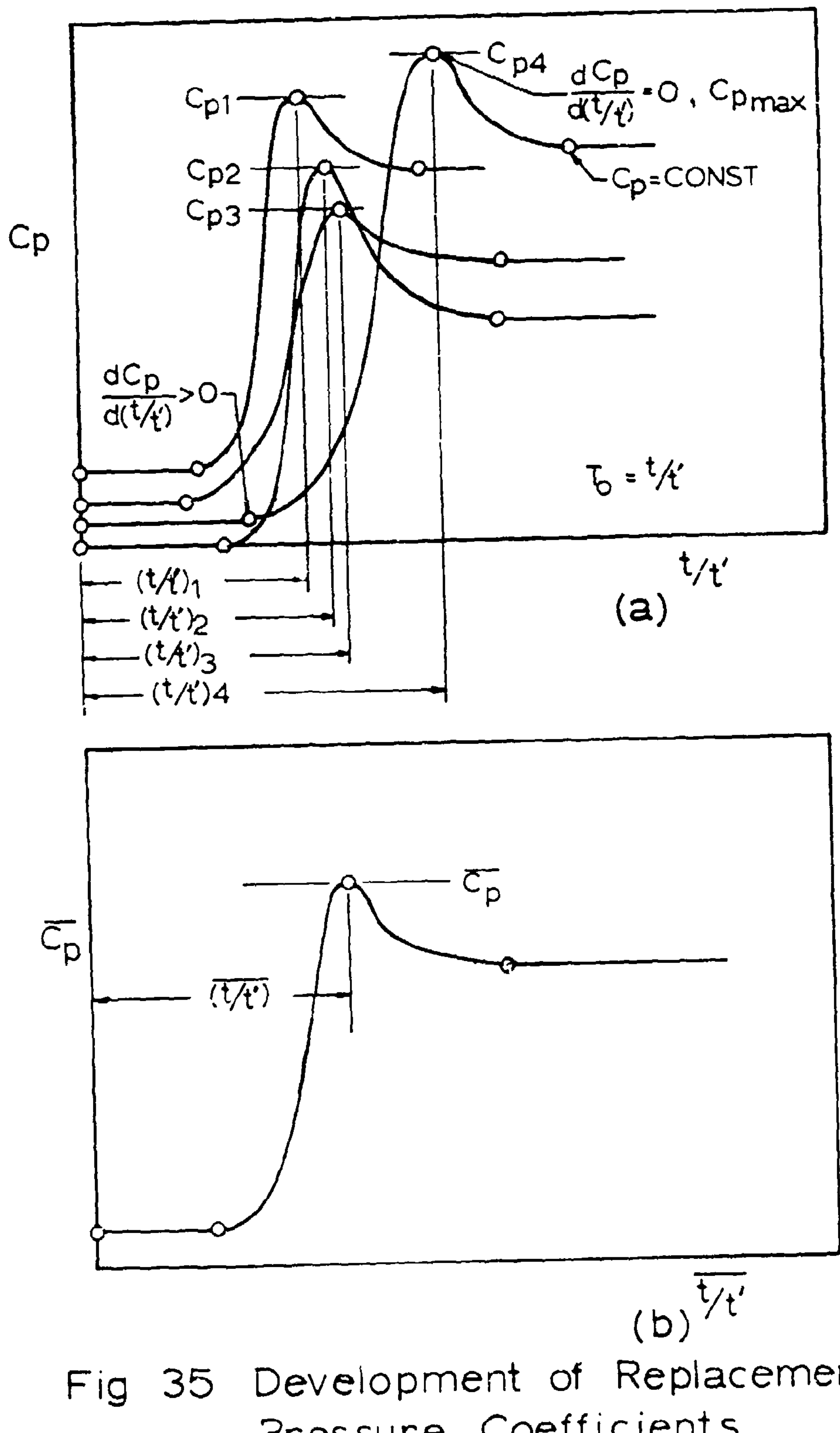


Fig 35 Development of Replacement Pressure Coefficients

over-all replacement curves are shown in Figs 36 and 37 for the solid flat and the ringslot parachute model, respectively. The numerical values of the double bar terms are shown in Section III of the Appendix. For certain tests of the ringslot parachute, the replacement curves were determined by a least-squares method on a computer because they were too complex to be analyzed in the manner described above.

C. Data Validation of the Pressure-Time Replacement Curves.

In order to check the validity of the replacement curves, the values of $\overline{\overline{C}}_{p_d}$ vs $\overline{\overline{T}}_o$ were combined to total parachute forces by means of the previously described integration process over the related parachute surfaces. For the final validation, the calculated parachute forces were compared with the measured parachute forces, which were averaged directly on the dimensionless time scale T_o.

For the purpose of this validation, the replacement curves shown in Figs 36 and 37 were converted to functions of average pressure coefficients vs radius with averaged dimensionless times as parameter. This is shown in Figs 38 and 39 for the solid flat and ringslot parachutes, respectively. These curves were then used in the integration process.

For the solid flat parachute, which showed excessive discrepancies in the validation checks based on individual runs, the calculated and measured forces obtained from the averaged values were then compared merely in the regions of maximum force development and at steady state. This process followed the scheme as indicated below

$$R = \frac{\int \overline{\overline{C}}_{p_d} \cos\theta \; dS}{\frac{1}{n} \sum_{n} F_n / q_n} \qquad (1)$$

For the solid flat parachute the ratios R, obtained by means of this formula, amounted for the maximum and for the steady state forces to 1.54 and 1.49, respectively. These deviations, based on all available pressure and force recordings, are on the same order as those of individual runs, and it was finally decided that the pressure and force data of the solid flat parachute given in Ref 1 do not justify further attempts to establish pressure-force relationships satisfactory for the calculation of parachute canopy stresses.

For the ringslot parachute, the preliminary comparison of the instantaneous forces calculated and measured showed better agreement. Therefore, the calculated instantaneous force, based on the averaged values of the replacement curves,

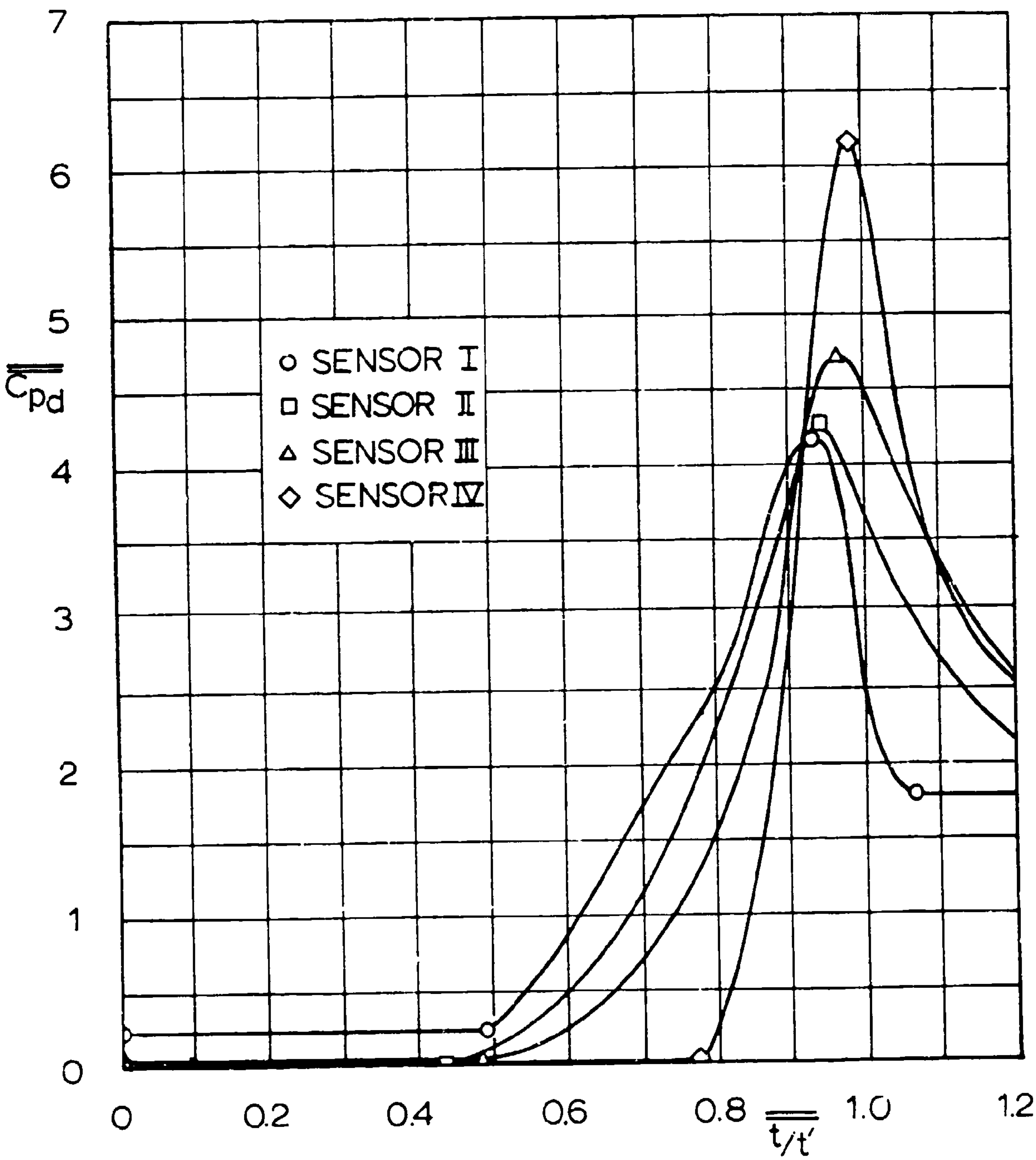


Fig 36 Replacement Pressure Coefficients for Solid Flat Circular Parachute

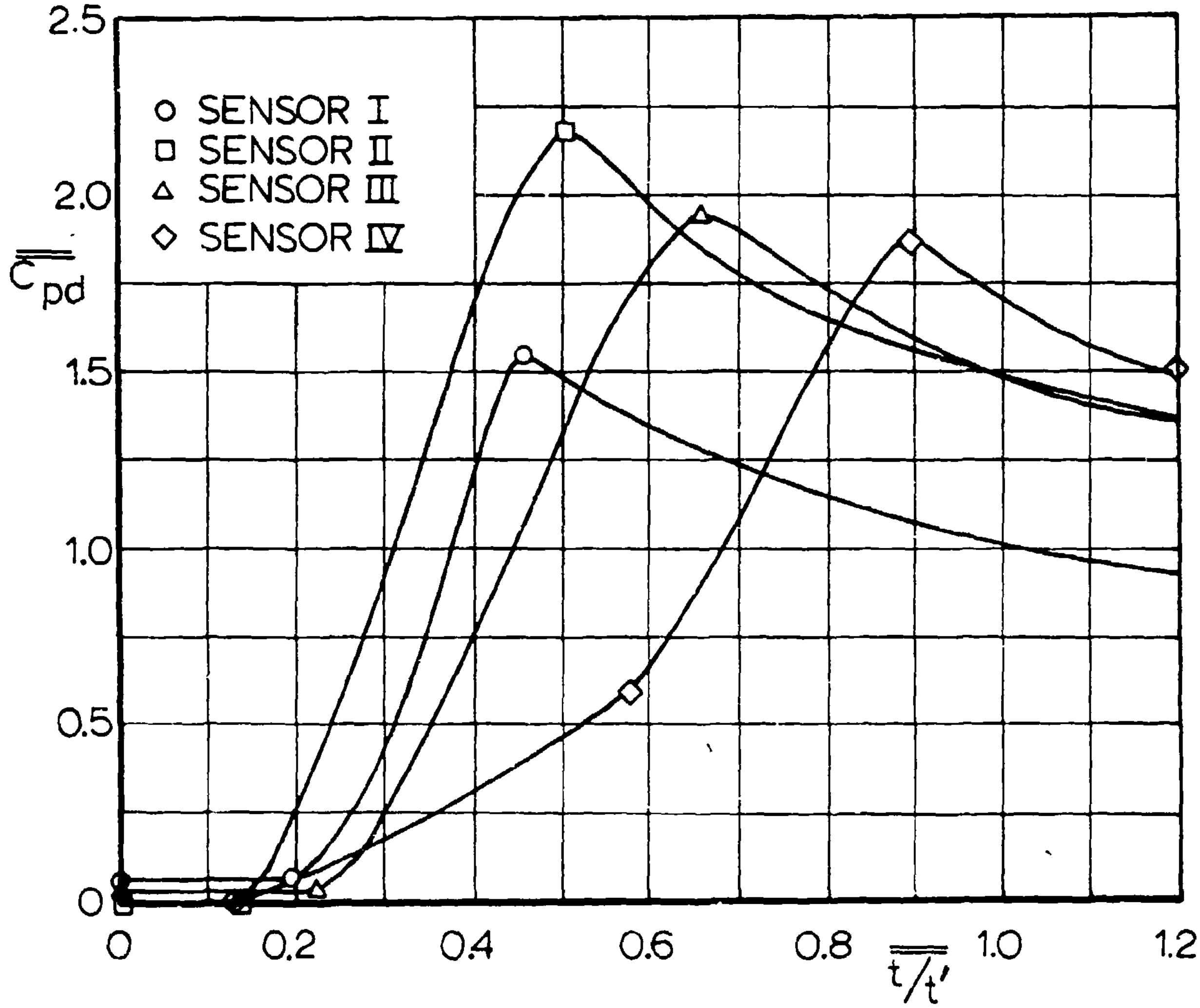


Fig 37 Replacement Pressure Coefficients for Ringslot Parachute

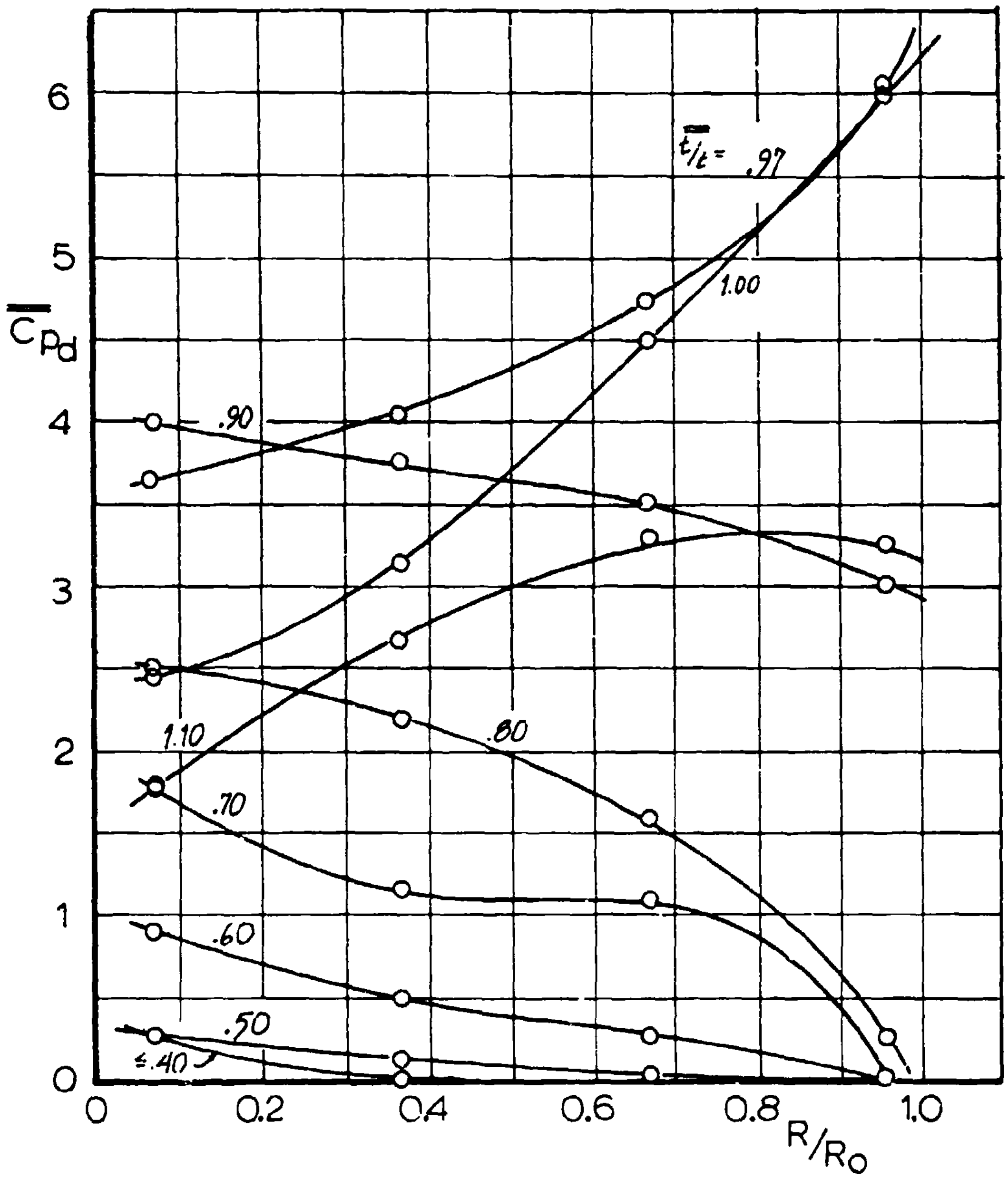


Fig 38 Pressure Distribution Based on Replacement Curves (Fig 36) vs Location for the Solid Flat Circular Parachute

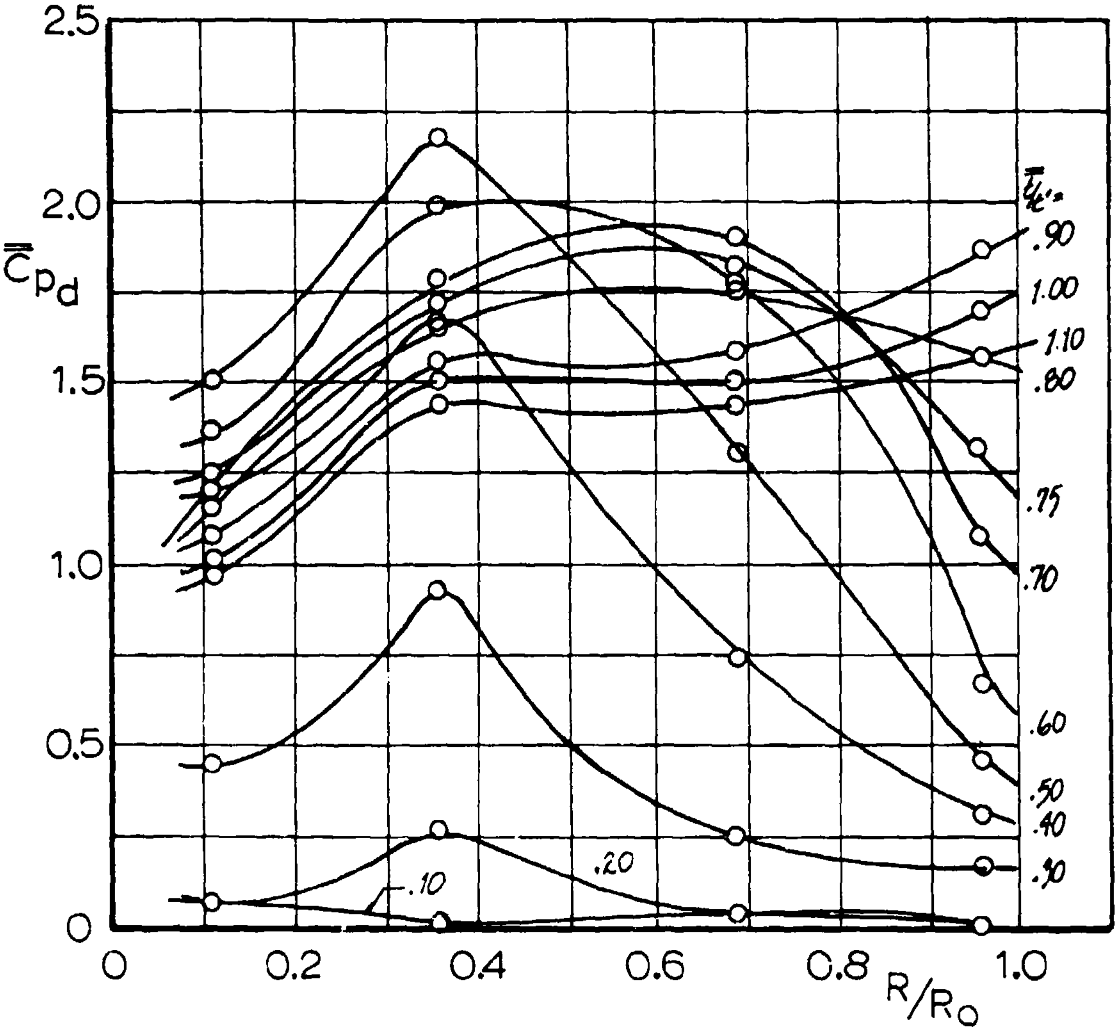


Fig 39 Pressure Distribution Based on Replacement Curves (Fig 37) vs Location for the Ringslot Parachute

is plotted in Fig 40 together with the corresponding averaged measured parachute force. One notices that the maxima of the calculated and measured averaged forces disagree by about 20%. However, the slope of the two comparative force curves is over a large region about the same. The over-all identity is improved if one allows a phase shift of the calculated force-time curve in the amount of $T_o = 0.1$. Again, in view of the complicated method of recording and the extensive averaging process, such a time shift does not seem to be unreasonable. Another encouraging sign is the fact that for steady-state condition the calculated and measured forces agree better than the maximum forces, namely, they differ merely by 11%.

Figure 41 shows the ratio of the calculated to measured forces during parachute inflation and under steady-state conditions. In the very early stage, the agreement of the parachute forces is rather poor but improves with time, and the ratio is, in general, within approximately 20%, if the time shift is accepted.

The test data of Refs 1 and 2 were also used to establish averaged drag coefficients from the averaged measured force. Relating the averaged drag area to the nominal canopy area as stated in Ref 1, the drag coefficients of the solid flat and ringslot parachute models are 0.73 and 0.41, respectively. However, determining the canopy surface area obtained from measuring the actual parachute models, the drag coefficients of the solid flat and ringslot models amount to 0.8/ and 0.47. Details of these derivations are shown in Table XXXIV in the Appendix.

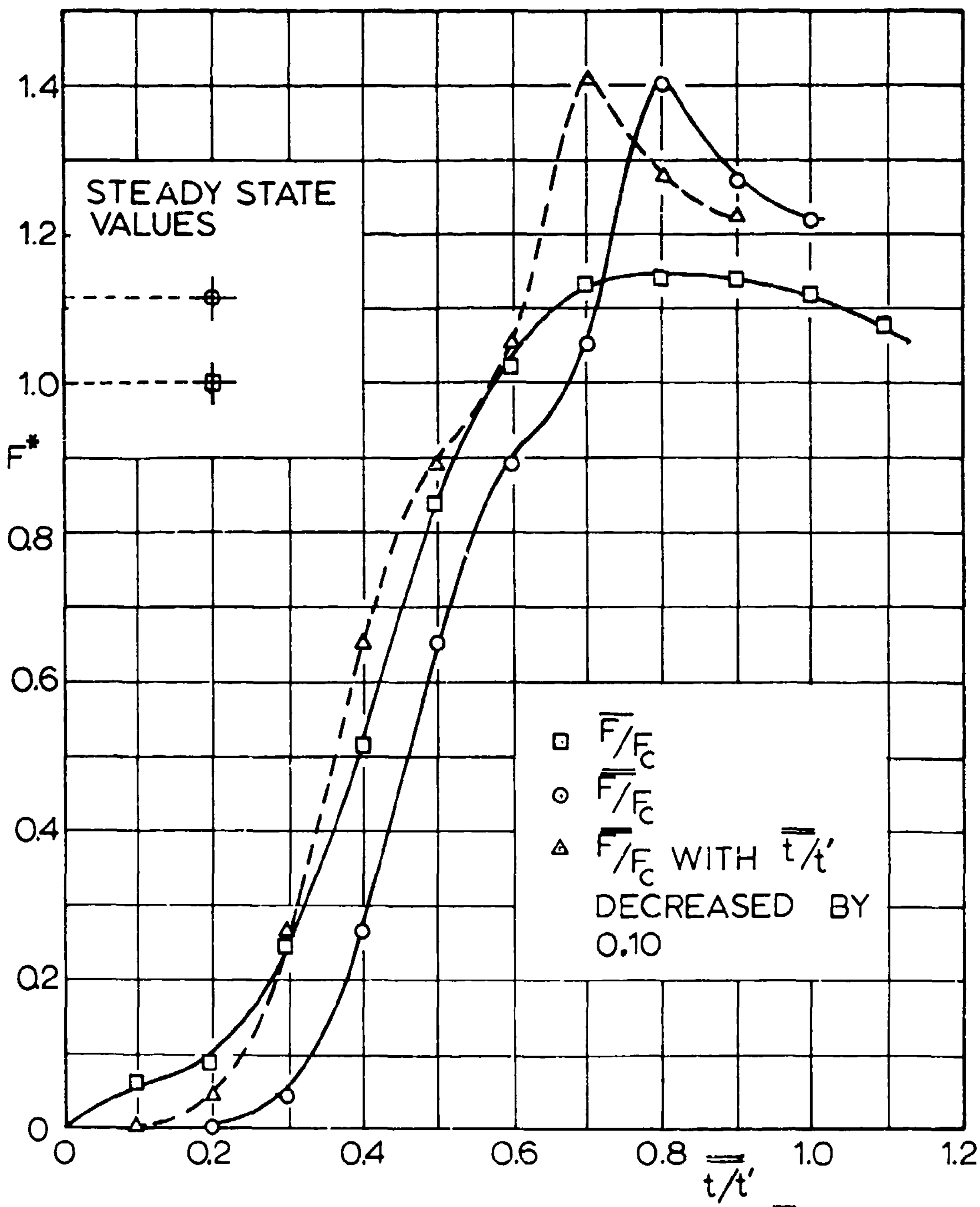


Fig 40 Averaged Measured Forces, $\overline{F}$, and Calculated Forces, $\overline{\overline{F}}$, based on Replacement Curves (Fig 37) for Ringslot Parachute

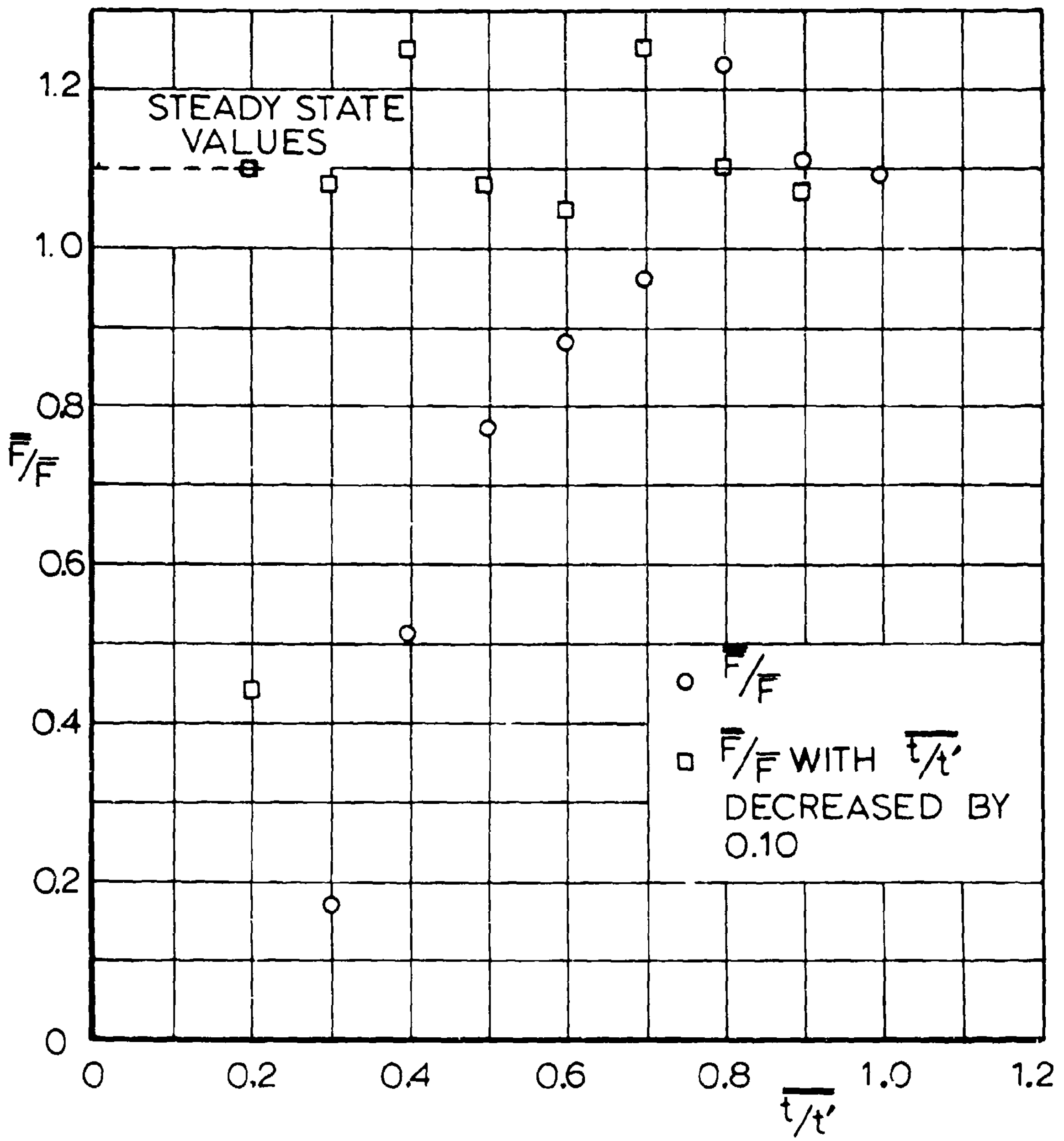


Fig 41 Ratio of Calculated Forces, based on Replacement Curves, and Averaged Measured Forces; Ringslot Parachute

III. RESULTS

In view of the presented analysis, the attempt of correlating the measured instantaneous parachute force with the measured pressure distribution, based on Refs 1 and 2, has failed for the solid flat parachute. However, in connection with this problem the following fact might be interesting. In Ref 4 a pressure distribution is shown which was obtained on a rigidized hemispherical parachute model consisting of a wire frame covered with parachute cloth, 1.1 oz nylon, MIL-C-7020D Type I. As an exploratory study, the pressure distribution given in Ref 4 was applied to a fully inflated parachute having the profile as given in Ref 1. The parameter of correlation was the distance measured from the center of the vent. The pressure profile was then integrated over the parachute surface in view of the aerodynamic drag force. The parachute force calculated in this manner differed from the measured average forces given in Ref 2 by merely 4%.

This result suggests a number of conclusions, one of which is that for the steady-state condition the pressure distribution of a porous hemisphere and porous ellipsoid cannot differ significantly from each other.

A comparison between the calculated and measured parachute forces of the ringslot parachute as reported in Ref 1 showed for the steady-state condition a discrepancy of 12%. This agreement is not very satisfactory, but, since no other information is presently available, the obtained averaged force and pressure values were correlated in view of the concept postulated in the introduction. The result of this entire effort is then shown in Fig 42 which shows values of the differential pressure coefficient vs the canopy radius with the ratio of instantaneous to constant force as parameter. Under consideration of the shown discrepancies, this information is recommended for use in stress analyses of ringslot parachutes in subsonic flow, until more satisfactory data will be available.

Figure 42 indicates for the force parameters $\tilde{F}/F_c$ = 1.05 and 1.10 more than one value of the pressure coefficient for the same location. This results from the fact that the parachute force varies with respect to time and has an increasing phase, a peak and a decreasing phase. Therefore, the parachute canopy experiences in the peak force region identical force levels at different times (Fig 40). During this period the degree of canopy inflation varies and the same force level is achieved with different values of differential pressure. Therefore, several functions of C_{p_d} vs R/R_0 appear in Fig 42. For

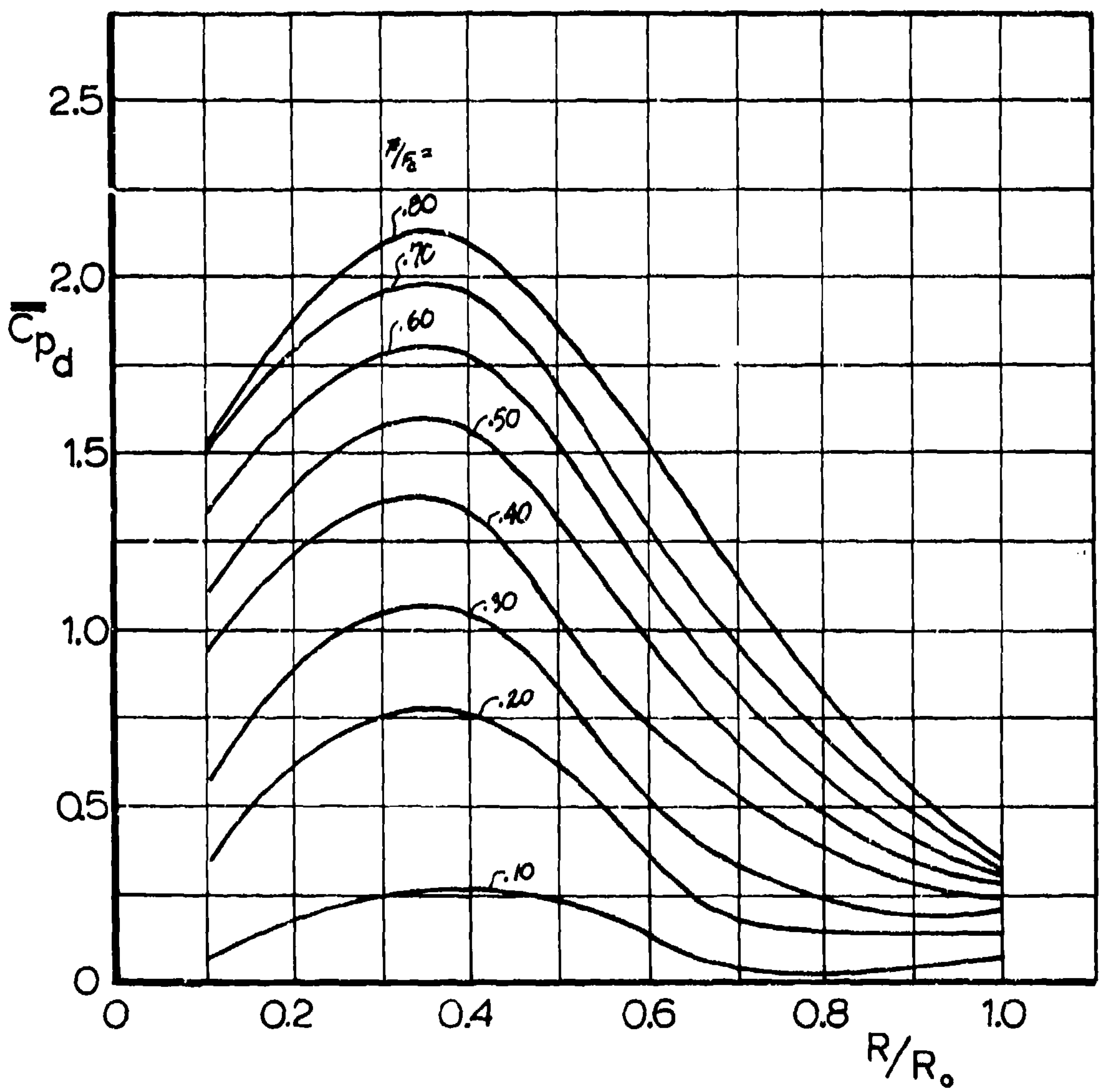


Fig 42 Pressure Distribution Based on Replacement Curves (Fig 37) vs Location for the Ringslot Parachute

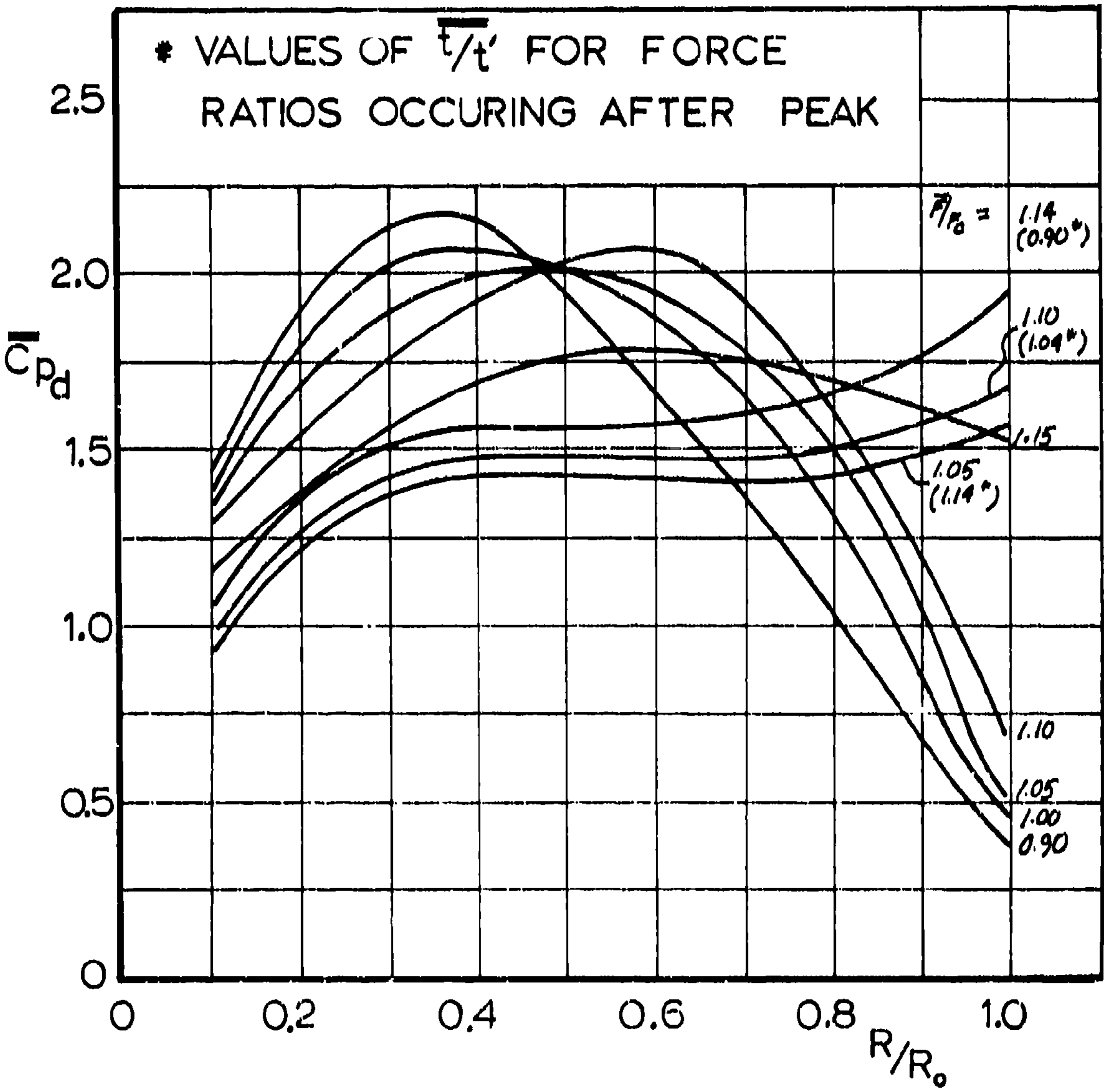

* VALUES OF $\overline{t}/t'$ FOR FORCE RATIOS OCCURING AFTER PEAK
2.5
2.0
1.5
1.0
0.5
0
$\overline{C}p_d$
0
0.2
0.4
0.6
0.8
1.0
R/R_o
$\overline{F}/F_o$ =
1.14 (0.90*)
1.10 (1.04*)
1.15
1.05 (1.14*)
1.10
1.05
1.00
0.90

Fig 42 (cont'd)

a stress analysis the product of differential pressure and bulge radius of the inflated gore determine the stress, $f = \Delta p.r_b$ (Refs 5,6), and one cannot simply assume that the maximum differential pressure will always cause the maximum stress.

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2. Unpublished data obtained from Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio (Mr. James H. DeWeese, Project Engineer).

3. Performance of and Design Criteria for Deployable Aerodynamic Decelerators, Technical Report No. ASD-TR-61-579, December 1963.

4. Heinrich, H. G., et.al, Progress Report No. 18, Theoretical Parachute Investigations, 1 June 1961 to 31 August 1961, Department of Aeronautics and Engineering Mechanics, University of Minnesota.

5. Heinrich, H. G., and Jamison, L. R. Jr.: Stress Analysis of a Parachute During Inflation and at Steady State, FDL-TDR-64-125, February 1965.

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APPENDIX

SECTION I. FORCE CALCULATION METHOD

The aerodynamic forces calculated from the pressure-time data of Ref 1 were obtained in the following manner. At a given time instant, $T_o = t/t^*$, for individual test measurements of C_{p_d}, or $T_o = t/t'$ for averaged data, a pressure distribution was established as described previously. For the same time instant, the canopy shape was constructed based on the geometry data also given in Ref 1. The pressures were then numerically integrated over the canopy shapes to yield the so-called calculated drag force. The individual steps are shown below.

1. Shape Study

Photographic analysis of the infinite mass openings was, in accordance with Ref 1, conducted by means of a high speed camera which photographed the opening from one side. This was done only for the test runs in which C_{p_d} was measured. The study presented in Ref 1 was based on the so-called "idealized photographic shape", presented here with related parameters shown in Fig 43. The shape parameters were non-dimensionalized by D_o and plotted vs t/t^* in Ref 1.

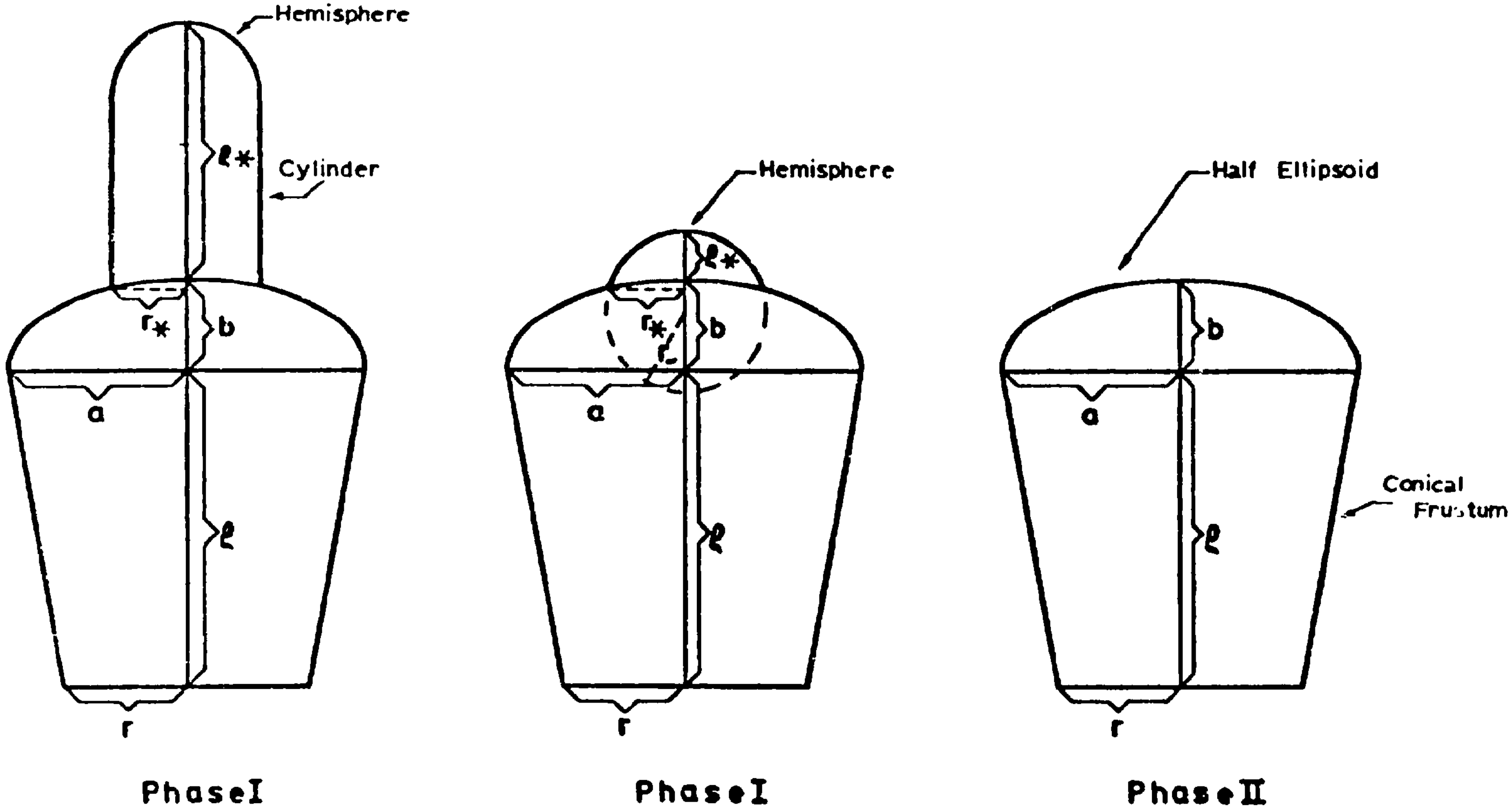
For integration of averaged pressures, $\overline{\overline{C}}_{p_d}$, the shape parameters of Ref 1 were replotted against a time scale of t/t' (Figs 44 and 45). This was possible since both t^* and t' are available for the tests in which the photographic study was performed.

For the numerical solution, the shape parameters related to a particular time instant were read and the canopy shape drawn accordingly.

2. Integration of Pressure over Canopy Surface

The pressure distribution shown previously was then integrated over the canopy shape at instants during the inflation. The component of force coinciding with the direction of the velocity, the aerodynamic drag, is

$$D = q \int_S C_{p_d} \cos\theta \; dS \qquad (2)$$



$\ell_* > r_* - b\left(1-\sqrt{1-\frac{r_*^2}{a^2}}\right)$ $\qquad$ $\ell_* \leq r_* - b\left(1-\sqrt{1-\frac{r_*^2}{a^2}}\right)$

Fig 43 Idealized Photographic Shape Symbols (from Ref. 1)

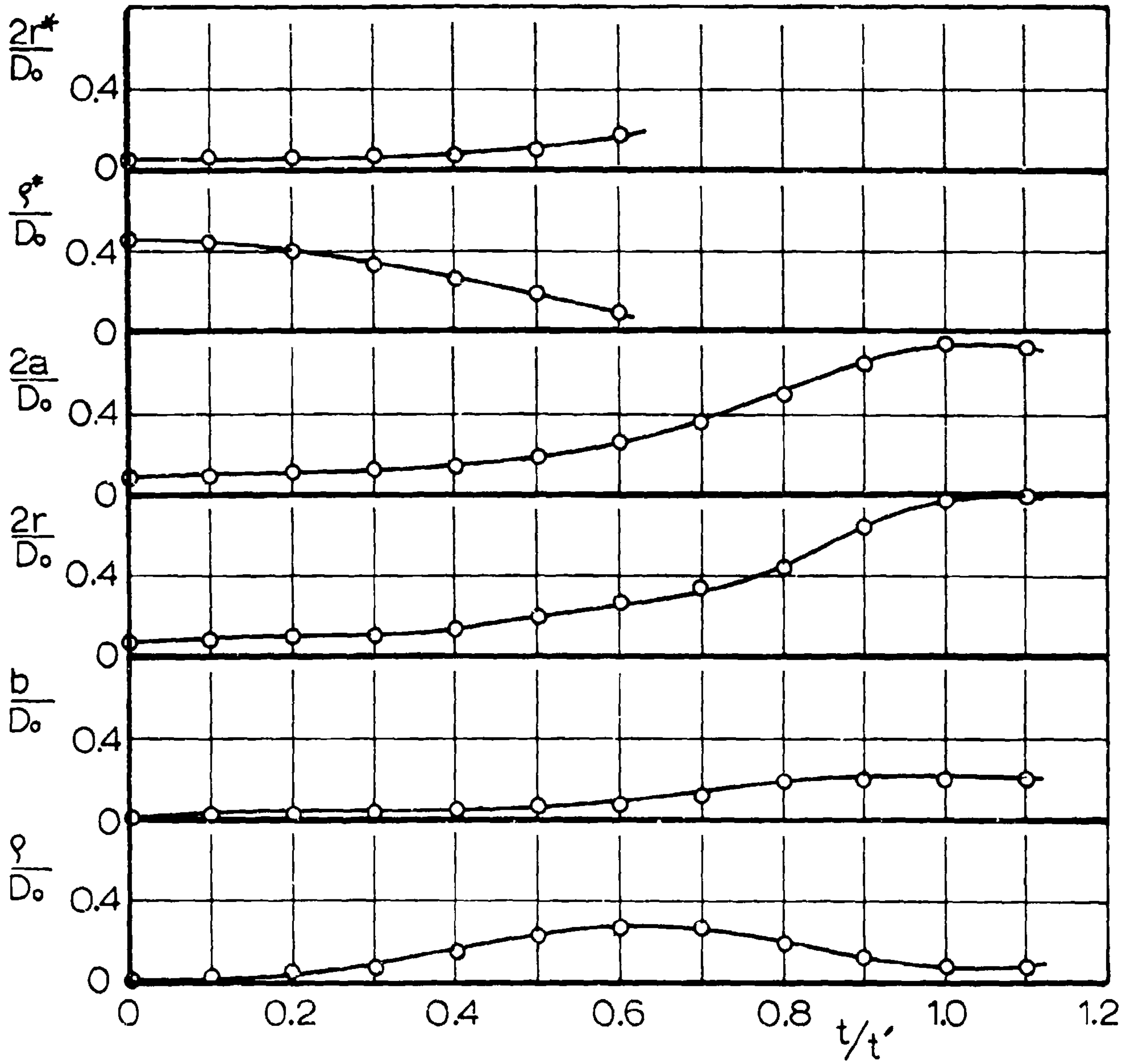


Fig 44 Averaged Values of Photographic Parameters for Solid Flat Circular Parachute (on converted time scale)

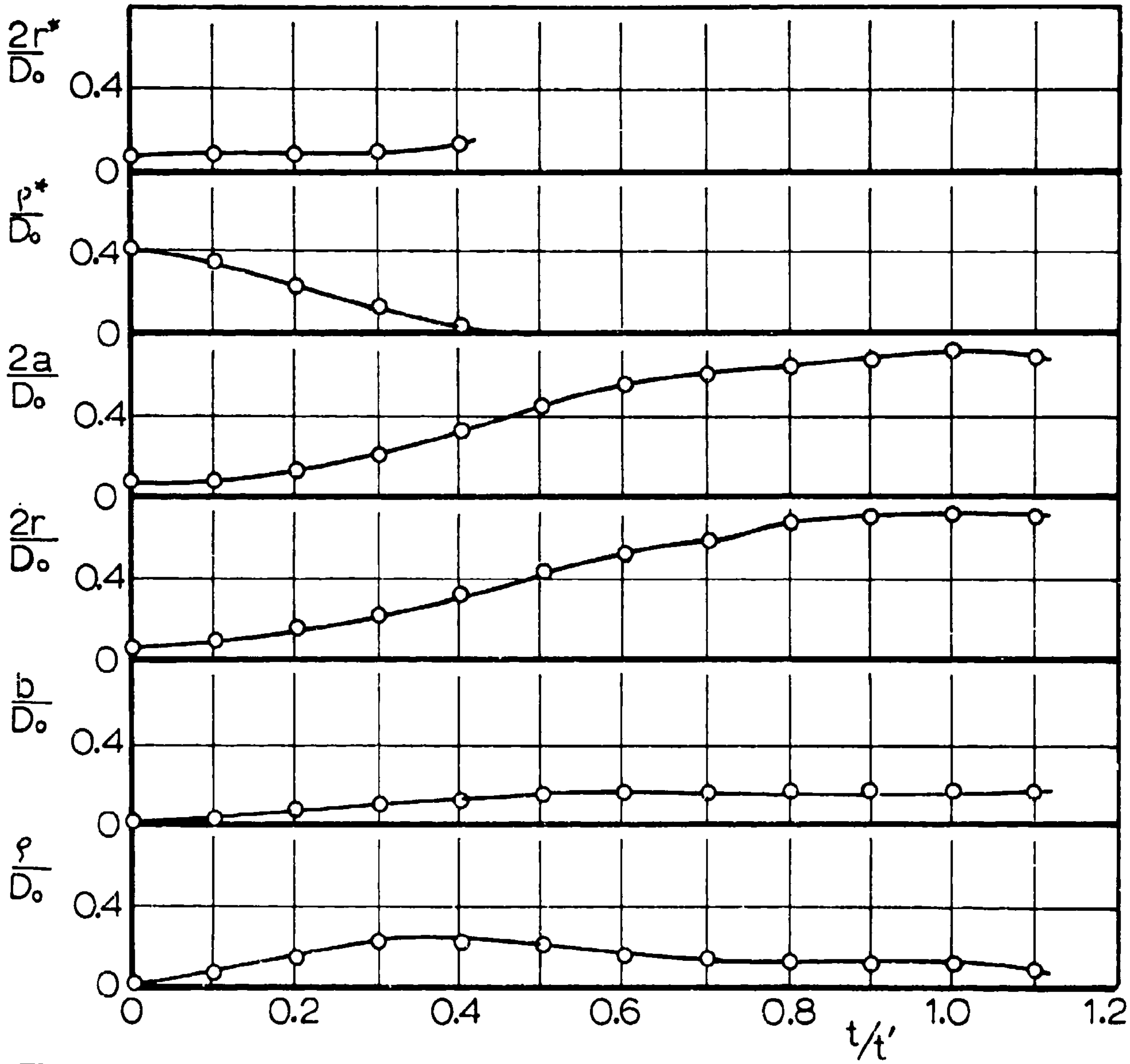


Fig 45 Averaged Values of Photographic Parameters for Ringslot Parachute (on converted time scale)

which can be approximated by

$$D = q \sum_{i=1}^{N=10} (C_{P_d} \cos\Theta \; \Delta S)_i \tag{3}$$

For the numerical solution, the canopy was divided into strips of area ΔS, which were approximated by the surface area of conical frustums with upper and lower radii r_1 and r_2 and slant height ΔR. Thus

$$\Delta S = \pi (r_1 + r_2) \Delta R \tag{4}$$

Since the shape parameters of Ref 1 are non-dimensionalized by D_o, the lengths r_1, r_2, and ΔR are transformed by the same denominator to r_1/D_o, r_2/D_o, and $\Delta R/D_o$ and one obtains

$$\Delta S = \pi D_o \left(\frac{r_1}{D_o} + \frac{r_2}{D_o}\right) D_o \left(\frac{\Delta R}{D_o}\right) \tag{5}$$

A slope meter was used to graphically determine θ, the angle between the velocity and the normal to the canopy surface, from the constructed plots of canopy shape. This process is illustrated in Fig 46.

3. Accuracy of Integration Process

Several methods were used to check the reproducibility of results obtained from the approximate integration process. For two calculations, two separate persons performed the integration for the same shapes and pressures, yielding results which differed by 5% and 2%. Thus the accuracy of the integration method was considered acceptable.

In order to determine the possibility of errors arising through the use of a slope meter for determination of the cosine-function, the following test was made. Arbitrary angles were constructed by subtending arcs of circles. These angles were measured by four persons independently, one with drafting equipment, one by using trigonometric functions, and two with the slope meter. The standard deviations of the cosine value determined by all four persons were on the average 0.69% of the value of the cosines as obtained by the four measurements. Thus it is felt that the accuracy of the slope meter measurement is good enough to justify its use in the integration process.

A study of different canopy shapes did not show that the process had great shape sensitivity. When the averaged pressure distribution of the circular flat canopy was integrated over an averaged shape constructed from the shape parameters of

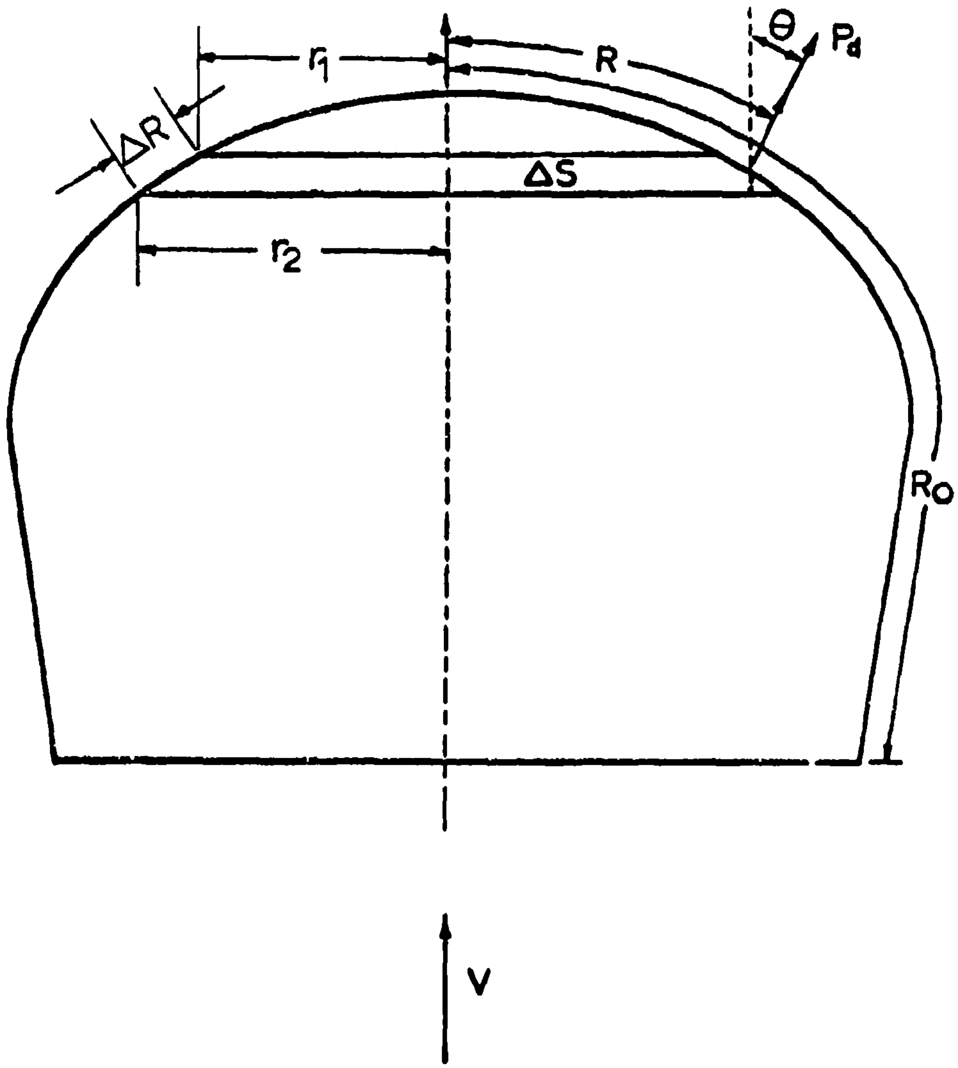


Fig. 46 Method Used to Approximate Integration of Pressure over Canopy Surface

Ref 1 at T_o = 1.00 and the same pressure distribution applied to the shape of a fully open model parachute obtained from a test at the University of Minnesota, the difference in calculated force amounted to only 2%.

This close agreement indicates that the shape data presented in Ref 1 for the circular flat canopy do agree with this independent measurement.

Since in Ref 1, the exact location of the pressure sensors on the solid flat parachute is not given, and an assumption had to be made, the dependency of the force calculation from shifting of the sensor locations was examined. Introducing an arbitrary shift as shown in Table I, it was found that for the steady-state conditions, the difference amounted to approximately 5%. This shows that a slight inaccuracy in assuming the location of the pressure transducers affects the results insignificantly.

In view of the results given above, the force calculation process is considered to be valid and exhibits a reasonable degree of accuracy.

TABLE I
EFFECT OF REARRANGING TAP LOCATIONS: ON STEADY STATE FORCES

	Taps at 0.00, 0.33, 0.67, 1.00 of R_O	Taps at 0.07, 0.33, 0.67, 0.96 of R_O	% Diff.
V_o = 70	1.46	1.53	4.8
V_o = 100	1.34	1.39	3.7
V_o = 130	1.46	1.33	9.9
V_o = 160	1.32	1.37	3.8
Avg.	1.40	1.40	0.0
$\overline{\overline{C}}_{P_d}$	1.50	1.49	1.7

ON OPENING CANOPY

	Taps at 0.00, 0.33, 0.67, 1.00 of R_O	Taps at 0.07, 0.33, 0.67, 0.96 of R_O	% Diff.
t/t' = 1.00	3.28	3.23	1.5
t/t' = 1.10	2.32	2.32	0.0

SECTION II

Figures 47 and 48 show pressure distributions derived from steady-state values of pressure coefficients given in Ref 1. Figure 47 indicates steady-state pressure coefficients for the solid flat parachute at each of the four test velocities as well as for the replacement pressure coefficients. The same information is shown for the ring-slot parachute in Fig 48.

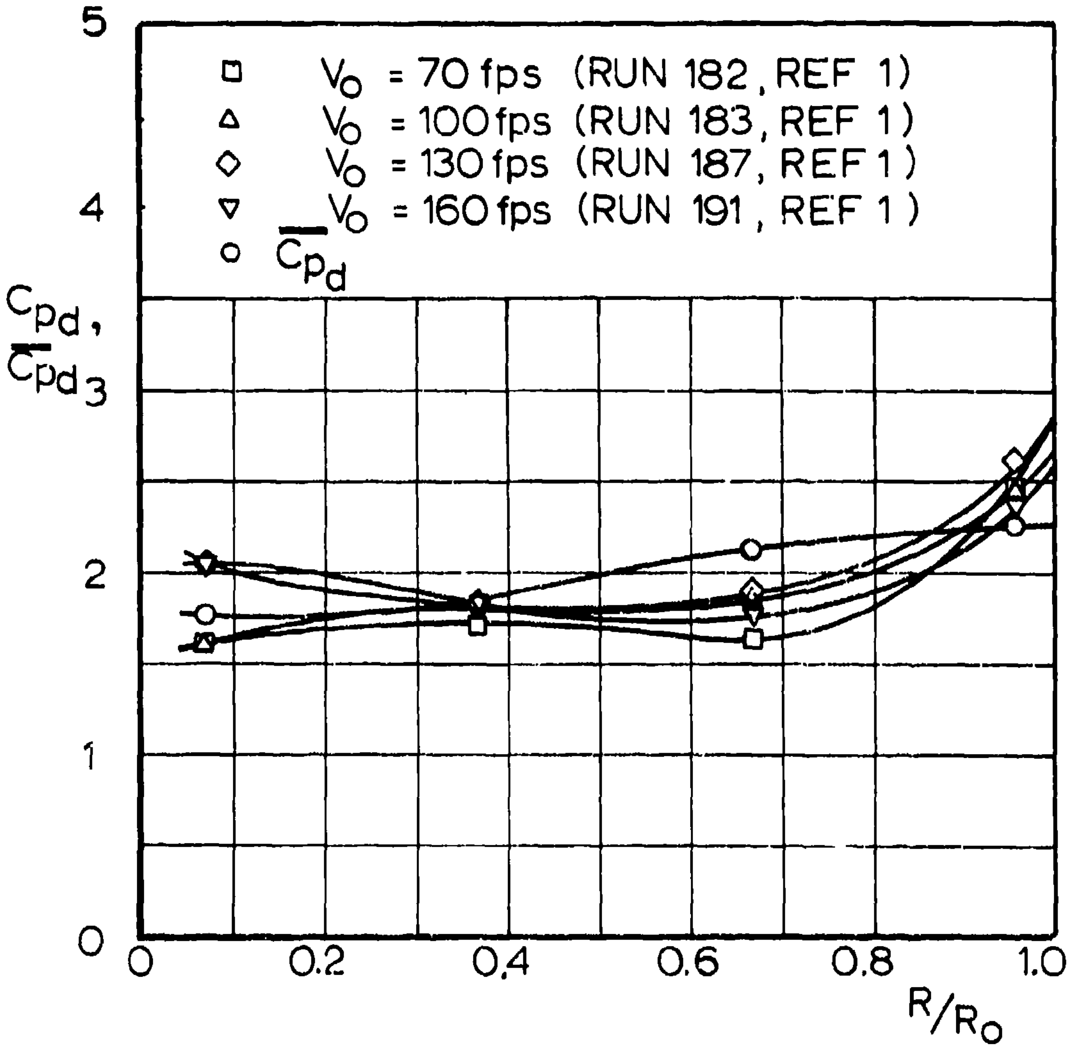


Fig 47 Steady State Pressure Distribution vs Location for Solid Flat Circular Parachute

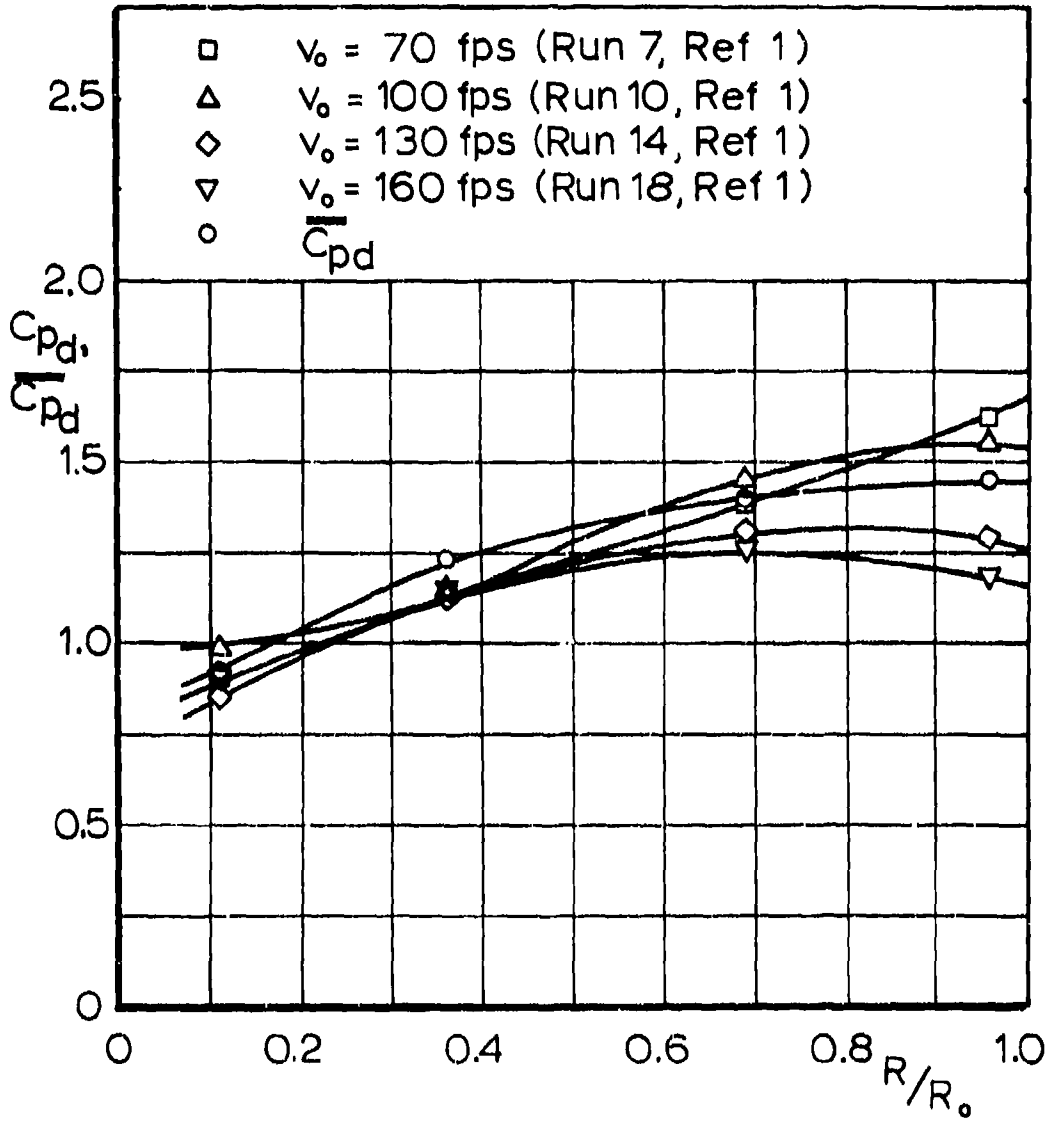


Fig 48 Steady State Pressure Distribution vs Location for Ringslot Parachute

SECTION III

The following tables II-XXXIII show the data points extracted from the pressure-time histories of Ref 1, the nondimensionalizing of the time scale for use in the determination of replacement curves C_{p_d} vs t/t', and the characteristic points used for the establishment of the so-called replacement curves.

TABLE II
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE
VELOCITY= 70 ft/sec SENSOR I

	RUN 211 t'= 0.3 sec		RUN 194 t'=0.25sec		RUN 182 t'=0.26 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.100	0.000	0.000	0.000	0.140
0.05	0.015	-0.100	0.012	0.000	0.013	0.140
0.10	0.030	-0.100	0.025	0.000	0.026	0.140
0.15	0.045	-0.100	0.038	0.000	0.039	0.140
0.20	0.060	-0.100	0.050	0.000	0.052	0.140
0.30	0.090	-0.100	0.075	0.000	0.078	0.140
0.35	0.105	-0.100	0.088	0.000	0.091	0.140
0.40	0.120	-0.100	0.100	0.000	0.104	0.140
0.45	0.135	-0.100	0.112	0.020	0.117	0.140
0.50	0.150	-0.100	0.125	0.250	0.130	0.180
0.55	0.165	-0.150	0.138	0.530	0.143	0.370
0.60	0.180	-0.180	0.150	0.800	0.156	0.680
0.65	0.195	-0.250	0.162	0.940	0.169	1.000
0.70	0.210	-0.450	0.175	1.050	0.182	1.450
0.75	0.225	-1.000	0.188	1.140	0.195	2.100
0.80	0.240	-1.150	0.200	1.270	0.208	2.300
0.85	0.255	-0.900	0.212	1.570	0.221	2.420
0.90	0.270	-0.700	0.225	2.450	0.234	3.000
0.95	0.285	-0.460	0.238	3.100	0.247	4.050
1.00	0.300	-0.370	0.250	2.500	0.260	4.700
1.05	0.315	-0.370	0.262	1.350	0.273	2.500
1.10			0.275	1.010	0.286	1.620
1.15			0.288	0.980	0.299	1.620
1.20			0.300	0.980		

TABLE II (cont'd)

CHARACTERISTIC VALUES						
	RUN 211		RUN 194		RUN 182	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.533	-0.100	0.432	0.000	0.469	0.140
$\frac{dC_p}{d(t/t')}=0$	0.767	-1.160	0.970	3.120	0.990	4.730
C_p = CONST.	0.983	-0.370	1.180	1.000	1.081	1.620

TABLE III

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY= 70 ft/sec SENSOR II

	RUN 211 t'=0.30 sec		RUN 194 t'=0.25 sec		RUN 182 t'=0.26 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.050	0.000	-0.070	0.000	0.000
0.05	0.015	-0.050	0.013	-0.060	0.013	0.000
0.10	0.030	-0.040	0.025	-0.070	0.026	0.000
0.15	0.045	-0.040	0.038	-0.070	0.039	0.000
0.20	0.060	-0.030	0.050	-0.080	0.052	0.000
0.25	0.075	-0.030	0.063	-0.080	0.065	0.000
0.30	0.090	-0.040	0.075	-0.070	0.078	0.000
0.35	0.105	-0.040	0.086	-0.070	0.091	0.000
0.40	0.120	-0.040	0.100	-0.080	0.104	0.000
0.45	0.135	-0.070	0.113	-0.070	0.117	0.000
0.50	0.150	-0.100	0.125	-0.030	0.130	0.150
0.55	0.165	-0.190	0.138	0.050	0.143	0.250
0.60	0.180	-0.290	0.150	0.130	0.156	0.450
0.65	0.195	-0.450	0.163	0.250	0.169	0.620
0.70	0.210	-0.670	0.175	0.360	0.182	0.890
0.75	0.225	-0.950	0.186	0.510	0.195	1.180
0.80	0.240	-1.320	0.200	0.730	0.208	1.570
0.85	0.255	-2.150	0.213	1.000	0.221	2.050
0.90	0.270	-1.620	0.225	1.620	0.234	2.650
0.95	0.285	-1.440	0.238	2.720	0.247	4.100
1.00	0.300	-1.320	0.250	2.350	0.260	4.440
1.05	0.315	-1.260	0.263	1.420	0.273	2.900
1.10	0.330	-1.160	0.275	1.020	0.286	2.250
1.15	0.345	-1.070	0.286	0.980	0.299	2.050
1.20	0.360	-1.000	0.300	0.980	0.312	1.950
1.25	0.375	-0.910			0.325	1.910
1.30	0.390	-0.840			0.338	1.870
1.35	0.405	-0.750			0.351	1.820
1.40	0.420	-0.680			0.364	1.730
1.45	0.435	-0.630			0.377	1.650
1.50	0.450	-0.630			0.390	1.600
1.55	0.465	-0.630			0.403	1.590

TABLE III (cont'd)

CHARACTERISTIC VALUES						
	RUN 211		RUN 194		RUN 182	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.400	-0.040	0.448	-0.070	0.458	0.000
$\frac{dC_p}{d(t/t')}=0$	0.833	-2.230	0.960	2.730	0.981	4.450
C_p = CONST.	1.450	-0.630	1.140	1.000	1.500	1.590

TABLE IV
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE
VELOCITY = 70 ft/sec SENSOR III

	RUN 211 t' = 0.30 sec		RUN 194 t' = 0.25 sec		RUN 182 t' = 0.26 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	-0.080	0.000	0.100
0.05	0.015	0.000	0.012	-0.080	0.013	0.060
0.10	0.030	0.000	0.025	-0.080	0.026	0.060
0.15	0.045	0.000	0.038	-0.080	0.039	0.070
0.20	0.060	0.000	0.050	-0.080	0.052	0.090
0.25	0.075	0.000	0.062	-0.080	0.065	0.120
0.30	0.090	0.000	0.075	-0.080	0.078	0.140
0.35	0.105	0.000	0.088	-0.080	0.091	0.180
0.40	0.120	0.000	0.100	-0.080	0.104	0.240
0.45	0.135	0.000	0.112	-0.080	0.117	0.340
0.50	0.150	0.000	0.125	-0.080	0.130	0.400
0.55	0.165	0.000	0.138	-0.080	0.143	0.580
0.60	0.180	0.000	0.150	-0.080	0.156	0.760
0.65	0.195	0.000	0.162	-0.080	0.169	0.930
0.70	0.210	0.000	0.175	-0.080	0.182	1.060
0.75	0.225	-0.150	0.188	-0.060	0.195	1.250
0.80	0.240	-0.950	0.200	0.000	0.208	1.650
0.85	0.255	-1.450	0.212	0.130	0.221	2.190
0.90	0.270	-2.250	0.225	0.950	0.234	2.820
0.95	0.285	-2.510	0.238	3.300	0.247	4.210
1.00	0.300	-2.100	0.250	2.500	0.260	5.330
1.05	0.315	-1.800	0.262	1.370	0.273	3.910
1.10	0.330	-1.310	0.275	1.130	0.286	3.380
1.15	0.345	-0.950	0.288	1.070	0.299	3.120
1.20	0.360	-0.700	0.300	1.010	0.312	2.800
1.25	0.375	-0.600	0.312	1.000	0.325	2.540
1.30	0.390	-0.550			0.338	2.320
1.35	0.405	-0.510			0.351	2.150
1.40	0.420	-0.480			0.364	2.000
1.45					0.377	1.860
1.50					0.390	1.800
1.55					0.403	1.740

TABLE IV (cont'd)

CHARACTERISTIC VALUES						
	RUN 211		RUN 194		RUN 182	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.703	0.000	0.720	-0.080	0.150	0.060
$\frac{dC_p}{d(t/t')} = 0$	0.933	-2.550	0.964	3.320	1.000	5.330
$C_p =$ CONST.	1.360	-0.480	1.220	1.000	1.692	1.670

TABLE V

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 70 ft/sec SENSOR IV

	RUN 211 $t' = 0.30$ sec		RUN 194 $t' = 0.25$ sec		RUN 182 $t' = 0.26$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.05	0.015	0.000	0.012	0.000	0.013	0.000
0.10	0.030	0.000	0.025	0.000	0.026	0.000
0.15	0.045	0.000	0.038	0.000	0.039	0.000
0.20	0.060	0.000	0.050	0.000	0.052	0.000
0.25	0.075	0.000	0.062	0.000	0.065	0.000
0.30	0.090	0.000	0.075	0.000	0.078	0.000
0.35	0.105	0.000	0.088	0.000	0.091	0.000
0.40	0.120	0.000	0.100	0.000	0.104	0.000
0.45	0.135	0.000	0.112	0.000	0.117	0.000
0.50	0.150	0.000	0.125	0.000	0.130	0.000
0.55	0.165	0.000	0.138	0.000	0.143	0.000
0.60	0.180	0.000	0.150	0.000	0.156	0.000
0.65	0.195	0.000	0.162	0.000	0.169	0.000
0.70	0.210	0.000	0.175	0.000	0.182	0.000
0.75	0.225	0.000	0.188	0.180	0.195	0.000
0.80	0.240	-0.010	0.200	0.260	0.208	0.000
0.85	0.255	-0.050	0.212	0.450	0.221	0.000
0.90	0.270	-0.650	0.225	0.800	0.234	0.020
0.95	0.285	-4.400	0.238	1.700	0.247	0.070
1.00	0.300	-3.400	0.250	1.650	0.260	7.850
1.05	0.315	-2.140	0.262	1.020	0.273	5.800
1.10	0.330	-1.900	0.275	0.970	0.286	3.870
1.15	0.345	-1.730	0.288	0.950	0.299	3.410
1.20	0.360	-1.550	0.300	0.950	0.312	3.140
1.25	0.375	-1.380			0.325	2.910
1.30	0.390	-1.300			0.338	2.850
1.35	0.405	-1.300			0.351	2.690
1.40					0.364	2.540
1.45					0.377	2.430
1.50					0.390	2.420

TABLE V (cont'd)

CHARACTERISTIC VALUES						
	RUN 211		RUN 194		RUN 182	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.750	0.000	0.728	0.000	0.888	0.000
$\frac{dC_p}{d(t/t')} = 0$	0.967	-4.620	0.972	2.450	1.019	7.890
C_p = CONST.	0.888	-1.300	1.019	0.950	1.462	2.420

TABLE VI

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY= 100 ft/sec SENSOR I

	RUN 216 $t'=0.22$ sec		RUN 200 $t'=0.2$ sec		RUN 183 $t'=0.22$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.300	0.000	0.000	0.000	0.150
0.05	0.011	-0.300	0.010	0.000	0.011	0.150
0.10	0.022	-0.300	0.020	0.000	0.022	0.150
0.15	0.033	-0.300	0.030	0.000	0.033	0.150
0.20	0.044	-0.300	0.040	0.000	0.044	0.150
0.25	0.055	-0.300	0.050	0.000	0.055	0.150
0.30	0.066	-0.300	0.060	0.000	0.066	0.150
0.35	0.077	-0.300	0.070	0.000	0.077	0.150
0.40	0.088	-0.300	0.080	0.000	0.088	0.150
0.45	0.099	-0.300	0.090	0.000	0.099	0.150
0.50	0.110	-0.330	0.100	0.000	0.110	0.150
0.55	0.121	-0.350	0.110	0.000	0.121	0.150
0.60	0.132	-0.410	0.120	0.150	0.132	0.150
0.65	0.143	-0.480	0.130	0.500	0.143	0.150
0.70	0.154	-0.550	0.140	1.120	0.154	0.290
0.75	0.165	-0.680	0.150	1.700	0.165	1.600
0.80	0.176	-0.870	0.160	2.070	0.176	2.020
0.85	0.187	-1.030	0.170	2.370	0.187	2.220
0.90	0.198	-1.200	0.180	2.700	0.198	2.530
0.95	0.209	-0.520	0.190	3.200	0.209	3.230
1.00	0.220	-0.500	0.200	3.530	0.220	4.110
1.05	0.231	-0.500	0.210	2.250	0.231	1.630
1.10	0.242	-0.500	0.220	1.850	0.242	1.600
1.15			0.230	1.700		
1.20			0.240	1.630		
1.25			0.250	1.580		
1.30			0.260	1.550		
1.35			0.270	1.510		
1.40			0.280	1.480		
1.45			0.290	1.450		
1.50			0.300	1.430		
2.50			0.500	1.330		

TABLE VI (cont'd)

CHARACTERISTIC VALUES						
	RUN 216		RUN 200		RUN 183	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.454	-0.030	0.550	0.000	0.682	0.150
$\frac{dC_p}{d(t/t')}=0$	0.910	-1.200	0.980	3.540	0.990	4.120
$C_p =$ CONST.	0.959	-0.050	2.500	1.330	1.041	1.600

TABLE VII

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 100 ft/sec SENSOR II

	RUN 216 $t' = 0.22$ sec		RUN 200 $t' = 0.20$ sec		RUN 183 $t' = 0.22$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	0.000	0.000	0.000
0.05	0.011	0.000	0.010	0.000	0.011	0.000
0.10	0.022	0.000	0.020	0.000	0.022	0.000
0.15	0.033	0.000	0.030	0.000	0.033	0.000
0.20	0.044	0.000	0.040	0.000	0.044	0.000
0.25	0.055	-0.010	0.050	0.000	0.055	0.000
0.30	0.066	-0.040	0.060	0.000	0.066	0.000
0.35	0.077	-0.050	0.070	0.000	0.077	0.000
0.40	0.088	-0.090	0.080	0.000	0.088	0.000
0.45	0.099	-0.140	0.090	0.000	0.099	0.000
0.50	0.110	-0.220	0.100	0.000	0.110	0.040
0.55	0.121	-0.310	0.110	0.000	0.121	0.080
0.60	0.132	-0.500	0.120	0.000	0.132	0.120
0.65	0.143	-0.720	0.130	0.000	0.143	0.440
0.70	0.154	-0.830	0.140	0.050	0.154	0.970
0.75	0.165	-0.930	0.150	0.530	0.165	1.380
0.80	0.176	-1.000	0.160	1.800	0.176	1.690
0.85	0.187	-1.150	0.170	2.470	0.187	2.300
0.90	0.198	-1.260	0.180	2.800	0.198	3.000
0.95	0.209	-1.370	0.190	3.350	0.209	4.560
1.00	0.220	-1.500	0.200	3.420	0.220	4.250
1.05	0.231	-1.980	0.210	3.100	0.231	3.150
1.10	0.242	-0.850	0.220	2.750	0.242	2.650
1.15	0.253	-0.640	0.230	2.450	0.253	2.370
1.20	0.264	-0.610	0.240	2.240	0.264	2.220
1.25	0.275	-0.600	0.250	2.050	0.275	2.110
1.30	0.286	-0.600	0.260	1.870	0.286	2.030
1.35	0.297	-0.600	0.270	1.750	0.297	1.980
1.40	0.308	-0.600	0.280	1.670	0.308	1.930
1.45		-0.600	0.290	1.620	0.319	1.880
1.50		-0.600	0.300	1.600	0.330	1.860
1.55		-0.600		1.600	0.341	1.840

TABLE VII (cont'd)

CHARACTERISTIC VALUES						
	RUN 216		RUN 200		RUN 183	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.227	0.000	0.675	0.000	0.454	0.000
$\frac{dC_p}{d(t/t')} = 0$	1.060	-2.000	0.980	3.950	0.964	4.570
$C_p =$ CONST.	1.204	-0.600	1.480	1.600	1.550	1.840

TABLE VIII

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 100 ft/sec SENSOR III

	RUN 216 $t' = 0.22$ sec		RUN 200 $t' = 0.20$ sec		RUN 183 $t' = 0.22$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	0.230	0.000	0.000
0.05	0.011	-0.010	0.010	0.230	0.011	0.000
0.10	0.022	-0.020	0.020	0.230	0.022	0.000
0.15	0.033	-0.030	0.030	0.230	0.033	0.000
0.20	0.044	-0.040	0.040	0.230	0.044	0.000
0.25	0.055	-0.050	0.050	0.230	0.055	0.000
0.30	0.066	-0.050	0.060	0.230	0.066	0.000
0.35	0.077	-0.060	0.070	0.230	0.077	0.000
0.40	0.088	-0.070	0.080	0.230	0.088	0.080
0.45	0.099	-0.090	0.090	0.230	0.099	0.130
0.50	0.110	-0.130	0.100	0.230	0.110	0.180
0.55	0.121	-0.160	0.110	0.230	0.121	0.260
0.60	0.132	-0.210	0.120	0.230	0.132	0.370
0.65	0.143	-0.280	0.130	0.250	0.143	0.430
0.70	0.154	-0.390	0.140	0.570	0.154	0.530
0.75	0.165	-0.600	0.150	1.000	0.165	0.710
0.80	0.176	-0.690	0.160	1.150	0.176	0.900
0.85	0.187	-1.050	0.170	1.500	0.187	1.150
0.90	0.198	-2.240	0.180	2.350	0.198	1.880
0.95	0.209	-2.270	0.190	3.330	0.209	4.230
1.00	0.220	-1.600	0.200	3.050	0.220	3.950
1.05	0.231	-0.970	0.210	2.400	0.231	3.570
1.10	0.242	-0.750	0.220	1.930	0.242	2.980
1.15	0.253	-0.700	0.230	1.740	0.253	2.470
1.20	0.264	-0.700	0.240	1.600	0.264	2.150
1.25			0.250	1.500	0.275	1.950
1.30			0.260	1.470	0.286	1.850
1.35			0.270	1.450	0.297	1.850
1.40			0.280	1.440		

TABLE VIII (cont'd)

CHARACTERISTIC VALUES						
	RUN 216		RUN 200		RUN 183	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.000	0.000	0.635	0.230	0.355	0.000
$\frac{dC_p}{d(t/t')}=0$	0.932	-2.300	0.975	3.350	0.964	4.250
$C_p =$ CONST.	1.123	-0.700	1.400	1.440	1.300	1.850

TABLE IX

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 100 ft/sec SENSOR IV

	RUN 216 t'=0.22 sec		RUN 200 t'=0.20 sec		RUN 183 t'=0.22 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.100	0.000	0.200	0.000	0.000
0.05	0.011	-0.010	0.010	0.200	0.011	0.000
0.10	0.022	0.010	0.020	0.200	0.022	0.000
0.15	0.033	0.050	0.030	0.200	0.033	0.000
0.20	0.044	0.060	0.040	0.200	0.044	0.000
0.25	0.055	0.100	0.050	0.200	0.055	0.000
0.30	0.066	0.100	0.060	0.200	0.066	0.000
0.35	0.077	0.100	0.070	0.200	0.077	0.000
0.40	0.088	0.110	0.080	0.200	0.088	0.000
0.45	0.099	0.120	0.090	0.200	0.099	0.000
0.50	0.110	0.140	0.100	0.200	0.110	0.000
0.55	0.121	0.140	0.110	0.200	0.121	0.000
0.60	0.132	0.140	0.120	0.200	0.132	0.000
0.65	0.143	0.130	0.130	0.200	0.143	0.000
0.70	0.154	0.110	0.140	0.230	0.154	0.000
0.75	0.165	0.100	0.150	0.850	0.165	0.000
0.80	0.176	0.100	0.160	1.300	0.176	0.000
0.85	0.187	0.100	0.170	1.500	0.187	0.000
0.90	0.198	0.010	0.180	1.800	0.198	0.040
0.95	0.209	-0.400	0.190	2.300	0.209	0.180
1.00	0.220	-2.650	0.200	2.700	0.220	5.600
1.05	0.231	-1.600	0.210	2.100	0.231	5.200
1.10	0.242	-1.430	0.220	1.670	0.242	3.650
1.15	0.253	-1.320	0.230	1.510	0.253	3.270
1.20	0.264	-1.220	0.240	1.430	0.264	3.080
1.25	0.275	-1.150	0.250	1.390	0.275	2.890
1.30	0.286	-1.090	0.260	1.370	0.286	2.800
1.35	0.297	-1.050	0.270	1.350	0.297	2.750
1.40	0.308	-1.030			0.308	2.670
1.45	0.319	-1.000			0.319	2.610
1.50					0.330	2.550
1.55					0.341	2.540

TABLE IX (cont'd)

CHARAC.ERISTIC VALUES						
	RUN 216		RUN 200		RUN. 183	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.914	0.000	0.660	0.200	0.882	0.000
$\frac{dC_p}{d(t/t')}=0$	0.977	-2.710	0.985	2.710	1.027	6.580
C_p = CONST.	1.450	-1.000	1.325	1.350	1.636	2.490

TABLE X
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 130 ft/sec SENSOR I

	RUN 218 $t' = 0.17$ sec		RUN 203 $t' = 0.16$ sec		RUN 187 $t' = 0.17$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.270	0.000	0.000	0.000	0.250
0.05	0.008	-0.270	0.008	0.000	0.008	0.250
0.10	0.017	-0.270	0.016	0.000	0.017	0.250
0.15	0.026	-0.270	0.024	0.000	0.026	0.260
0.20	0.034	-0.270	0.032	0.000	0.034	0.260
0.25	0.042	-0.270	0.040	0.000	0.042	0.260
0.30	0.051	-0.270	0.048	0.000	0.051	0.260
0.35	0.060	-0.320	0.056	0.000	0.060	0.260
0.40	0.068	-0.380	0.064	0.000	0.068	0.260
0.45	0.076	-0.450	0.072	0.070	0.076	0.260
0.50	0.085	-0.500	0.080	0.250	0.085	0.270
0.55	0.094	-0.550	0.088	0.540	0.094	0.400
0.60	0.102	-0.630	0.096	0.770	0.102	1.700
0.65	0.110	-0.710	0.104	1.080	0.110	1.920
0.70	0.119	-0.800	0.112	1.200	0.119	2.130
0.75	0.128	-0.930	0.120	1.240	0.128	2.390
0.80	0.136	-1.080	0.128	2.100	0.136	3.450
0.85	0.144	-1.300	0.136	2.300	0.144	4.200
0.90	0.153	-1.390	0.144	2.270	0.153	4.610
0.95	0.162	-0.430	0.152	1.230	0.162	2.750
1.00	0.170	-0.430	0.160	1.080	0.170	2.050
1.05			0.168	1.070		
1.10			0.176	1.050		

TABLE X (cont'd)

CHARACTERISTIC VALUES						
	RUN 218		RUN 203		RUN 187	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.300	-0.270	0.406	0.000	0.500	0.250
$\frac{dC_p}{d(t/t')}=0$	0.880	-1.420	0.860	2.310	0.910	4.620
$C_p =$ CONST.	0.924	-0.430	1.094	1.050	1.029	2.050

TABLE XI
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 130 ft/sec SENSOR II

	RUN 218 $t' = 0.17$ sec		RUN 203 $t' = 0.16$ sec		RUN 187 $t' = 0.17$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.040	0.000	0.000	0.000	0.000
0.05	0.008	0.040	0.008	0.000	0.008	0.000
0.10	0.017	0.020	0.016	0.000	0.017	0.000
0.15	0.026	0.000	0.024	0.000	0.026	0.000
0.20	0.034	-0.040	0.032	0.000	0.034	0.000
0.25	0.042	-0.110	0.040	0.000	0.042	0.000
0.30	0.051	-0.170	0.048	0.000	0.051	0.000
0.35	0.060	-0.300	0.056	0.000	0.060	0.080
0.40	0.068	-0.440	0.064	0.000	0.068	0.210
0.45	0.076	-0.540	0.072	0.000	0.076	0.320
0.50	0.085	-0.710	0.080	0.000	0.085	0.490
0.55	0.094	-0.900	0.088	0.070	0.094	0.720
0.60	0.102	-1.020	0.096	0.850	0.102	0.950
0.65	0.110	-1.200	0.104	1.130	0.110	1.150
0.70	0.119	-1.350	0.112	1.320	0.119	1.450
0.75	0.128	-1.550	0.120	1.500	0.128	1.960
0.80	0.136	-1.740	0.128	1.930	0.136	2.450
0.85	0.144	-2.030	0.136	2.640	0.144	3.250
0.90	0.153	-2.270	0.144	2.600	0.153	3.850
0.95	0.162	-1.700	0.152	1.570	0.162	3.000
1.00	0.170	-0.620	0.160	1.120	0.170	2.560
1.05	0.179	-0.590	0.168	1.060	0.179	2.320
1.10	0.187	-0.560	0.176	1.050	0.187	2.250
1.15		-0.560		1.050	0.196	2.130
1.20		-0.560		1.050	0.204	2.060
1.25		-0.560		1.050	0.213	1.980
1.30					0.221	1.930
1.35					0.230	1.900
1.40					0.238	1.860
1.45					0.247	1.860

TABLE XI (cont'd)

CHARACTERISTIC VALUES						
	RUN 218		RUN 203		RUN 187	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.150	0.000	0.506	0.000	0.306	0.000
$\frac{dC_p}{d(t/t')} = 0$	0.935	-2.420	0.850	2.640	0.882	3.870
$C_p =$ CONST.	1.100	-0.560	1.131	1.050	1.429	1.860

TABLE XII
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE
VELOCITY = 130 ft/sec SENSOR III

	RUN 218 $t' = 0.17$ sec		RUN 203 $t' = 0.16$ sec		RUN 187 $t' = 0.17$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.030	0.000	-0.050	0.000	0.000
0.05	0.008	-0.030	0.008	-0.050	0.008	0.000
0.10	0.017	-0.030	0.016	-0.050	0.017	0.000
0.15	0.026	-0.030	0.024	-0.050	0.026	0.000
0.20	0.034	-0.030	0.032	-0.050	0.034	0.000
0.25	0.042	-0.030	0.040	-0.050	0.042	0.000
0.30	0.051	-0.030	0.048	-0.050	0.051	0.000
0.35	0.060	-0.030	0.056	-0.050	0.060	0.000
0.40	0.068	-0.030	0.064	-0.050	0.068	0.000
0.45	0.076	-0.030	0.072	-0.050	0.076	0.000
0.50	0.085	-0.030	0.080	-0.040	0.085	0.000
0.55	0.094	-0.030	0.088	0.000	0.094	0.000
0.60	0.102	-0.060	0.096	0.110	0.102	0.050
0.65	0.110	-0.160	0.104	0.200	0.110	0.150
0.70	0.119	-0.520	0.112	0.350	0.119	0.400
0.75	0.128	-1.050	0.120	0.950	0.128	0.800
0.80	0.136	-1.320	0.128	2.000	0.136	1.070
0.85	0.144	-1.580	0.136	2.490	0.144	1.700
0.90	0.153	-1.930	0.144	1.850	0.153	3.400
0.95	0.162	-1.980	0.152	1.430	0.162	3.270
1.00	0.170	-1.110	0.160	1.250	0.170	2.650
1.05	0.178	-0.980	0.168	1.130	0.178	2.300
1.10	0.187	-0.930	0.176	1.080	0.187	1.950
1.15	0.196	-0.870	0.184	1.060	0.196	1.880
1.20	0.204	-0.850			0.204	1.870

TABLE XII (cont'd)

CHARACTERISTIC VALUES						
	RUN 218		RUN 203		RUN 187	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.541	-0.030	0.475	-0.050	0.570	0.000
$\frac{dC_p}{d(t/t')}=0$	0.924	-2.000	0.844	2.490	0.924	3.470
$C_p =$ CONST.	1.200	-0.850	1.117	1.060	1.147	1.870

TABLE XIII

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE
VELOCITY = 130 ft/sec SENSOR IV

	RUN 218 t′ = 0.17 sec		RUN 203 t′ = 0.16 sec		RUN 187 t′ = 0.17 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	-0.050	0.000	0.000
0.05	0.008	0.000	0.008	-0.010	0.008	0.000
0.10	0.017	0.000	0.016	0.000	0.017	0.000
0.15	0.026	0.000	0.024	0.020	0.026	0.000
0.20	0.034	0.000	0.032	0.060	0.034	0.000
0.25	0.042	0.000	0.040	0.100	0.042	0.000
0.30	0.051	0.000	0.048	0.140	0.051	0.000
0.35	0.060	0.000	0.056	0.160	0.060	0.000
0.40	0.068	0.000	0.064	0.180	0.068	0.000
0.45	0.076	0.000	0.072	0.200	0.076	0.000
0.50	0.085	0.000	0.080	0.250	0.085	0.000
0.55	0.094	0.000	0.088	0.290	0.094	0.000
0.60	0.102	0.000	0.096	0.340	0.102	0.000
0.65	0.110	0.000	0.104	0.380	0.100	0.000
0.70	0.119	0.000	0.112	0.450	0.119	0.000
0.75	0.128	0.000	0.120	0.600	0.128	0.000
0.80	0.136	-0.010	0.128	1.000	0.136	0.000
0.85	0.144	-0.070	0.136	1.970	0.144	0.000
0.90	0.153	-2.750	0.144	1.000	0.153	3.250
0.95	0.162	-3.470	0.152	0.950	0.162	5.450
1.00	0.170	-1.750	0.160	0.890	0.170	4.250
1.05	0.178	-1.170	0.168	0.880	0.178	3.300
1.10	0.187	-1.020	0.176	0.870	0.187	3.030
1.15	0.196	-0.900			0.196	2.860
1.20	0.204	-0.860			0.204	2.820
1.25	0.212	-0.820			0.212	2.730
1.30	0.221	-0.800			0.220	2.670
1.35					0.228	2.640
1.40					0.236	2.620
1.45					0.244	2.610
1.50					0.252	2.600

TABLE XIII (cont'd)

CHARACTERISTIC VALUES						
	RUN 218		RUN 203		RUN 187	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.782	0.000	0.000	-0.050	0.847	0.000
$\frac{dC_p}{d(t/t')} = 0$	0.935	-3.480	0.850	1.970	0.953	5.450
C_p = CONST.	0.847	-0.800	0.953	0.870	1.441	2.600

TABLE XIV

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 160 ft/sec SENSOR I

	RUN $t' =$ sec		RUN $t' =$ sec		RUN 191 $t' = 0.14$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00					0.000	0.290
0.05					0.007	0.290
0.10					0.014	0.290
0.15					0.021	0.290
0.20					0.028	0.290
0.25					0.035	0.290
0.30					0.042	0.290
0.35					0.049	0.290
0.40					0.056	0.290
0.45					0.063	0.290
0.50					0.070	0.360
0.55					0.077	0.550
0.60					0.084	1.000
0.65					0.091	1.100
0.70					0.098	1.130
0.75					0.105	1.190
0.80					0.112	1.270
0.85					0.119	1.420
0.90					0.126	2.100
0.95					0.133	2.570
1.00					0.140	2.840
1.05					0.147	2.700
1.10					0.154	2.120
1.15					0.161	2.070
1.20					0.168	2.070

TABLE XIV (cont'd)

CHARACTERISTIC VALUES						
	RUN		RUN		RUN 191	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$					0.464	0.290
$\frac{dC_p}{d(t/t')}=0$					1.000	2.840
$C_p=$ CONST.					1.143	2.070

TABLE XV
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 160 ft/sec SENSOR II

	RUN t′= sec		RUN t′= sec		RUN 191 t′= 0.14 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00					0.000	0.000
0.05					0.007	0.000
0.10					0.014	0.000
0.15					0.021	0.000
0.20					0.028	0.000
0.25					0.035	0.000
0.30					0.042	0.000
0.35					0.049	0.000
0.40					0.056	0.000
0.45					0.063	0.000
0.50					0.070	0.000
0.55					0.077	0.010
0.60					0.084	0.110
0.65					0.091	0.650
0.70					0.098	1.220
0.75					0.105	1.400
0.80					0.112	1.770
0.85					0.119	1.820
0.90					0.126	2.620
0.95					0.133	2.930
1.00					0.140	2.980
1.05					0.147	2.910
1.10					0.154	2.700
1.15					0.161	2.400
1.20					0.168	2.150
1.25					0.175	1.960
1.30					0.182	1.880
1.35					0.189	1.850
1.40					0.196	1.850

TABLE XV (cont'd)

CHARACTERISTIC VALUES						
	RUN		RUN		RUN 191	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$					0.521	0.000
$\frac{dC_p}{d(t/t')}=0$					0.979	3.000
$C_p =$ CONST.					1.400	1.850

TABLE XVI

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY = 160 ft/sec SENSOR III

	RUN t'= sec		RUN t'= sec		RUN 191 t'= 0.14 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00					0.000	0.000
0.05					0.007	0.000
0.10					0.014	0.000
0.15					0.021	0.000
0.20					0.028	0.000
0.25					0.035	0.000
0.30					0.042	0.000
0.35					0.049	0.000
0.40					0.056	0.000
0.45					0.063	0.000
0.50					0.070	0.000
0.55					0.077	0.000
0.60					0.084	0.000
0.65					0.091	0.000
0.70					0.098	0.000
0.75					0.105	0.050
0.80					0.112	0.100
0.85					0.119	0.210
0.90					0.126	0.800
0.95					0.133	1.250
1.00					0.140	1.800
1.05					0.147	2.750
1.10					0.154	3.450
1.15					0.161	2.850
1.20					0.168	2.350
1.25					0.175	2.000
1.30					0.182	1.820
1.35					0.189	1.780
1.40					0.196	1.750

TABLE XVI (cont'd)

CHARACTERISTIC VALUES						
	RUN		RUN		RUN 191	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$					0.714	0.000
$\frac{dC_p}{d(t/t')}=0$					1.100	3.450
$C_p =$ CONST.					1.400	1.750

TABLE XVII

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

SOLID FLAT CIRCULAR PARACHUTE

VELOCITY= 160 ft/sec SENSOR IV

	RUN $t'=$ sec		RUN $t'=$ sec		RUN 191 $t'=0.14$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00					0.000	-0.110
0.05					0.007	-0.110
0.10					0.014	-0.110
0.15					0.021	-0.110
0.20					0.028	-0.110
0.25					0.035	-0.110
0.30					0.042	-0.110
0.35					0.049	-0.110
0.40					0.056	-0.120
0.45					0.063	-0.120
0.50					0.070	-0.120
0.55					0.077	-0.120
0.60					0.084	-0.120
0.65					0.091	-0.120
0.70					0.098	-0.120
0.75					0.105	-0.130
0.80					0.112	-0.130
0.85					0.119	-0.130
0.90					0.126	-0.130
0.95					0.133	-0.130
1.00					0.140	-0.130
1.05					0.147	2.000
1.10					0.154	4.750
1.15					0.161	3.500
1.20					0.168	2.800
1.25					0.175	2.550
1.30					0.182	2.430
1.35					0.189	2.380
1.40					0.196	2.350

TABLE XVII (cont'd)

CHARACTERISTIC VALUES						
	RUN		RUN		RUN 191	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$					1.021	-0.110
$\frac{dC_p}{d(t/t')} = 0$					1.100	4.750
$C_p =$ CONST.					1.393	2.350

TABLE XVIII
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 70 ft/sec SENSOR I

	RUN 34 $t' = 0.40$ sec		RUN 22 $t' = 0.39$ sec		RUN 7 $t' = 0.42$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.075	0.000	0.000	0.000	0.075
0.10	0.040	-0.065	0.039	0.000	0.042	0.075
0.20	0.080	-0.075	0.078	0.000	0.084	0.075
0.30	0.120	-0.150	0.117	0.320	0.126	0.350
0.40	0.160	-0.375	0.156	0.515	0.168	1.277
0.50	0.200	-0.574	0.195	0.700	0.210	1.300
0.60	0.240	-0.500	0.234	0.940	0.252	1.275
0.70	0.280	-0.475	0.273	0.870	0.294	1.200
0.80	0.320	-0.450	0.312	0.750	0.336	1.050
0.90	0.360	-0.425	0.351	0.650	0.378	0.950
1.00	0.400	-0.425	0.390	0.625	0.420	0.900
1.10	0.440	-0.423	0.429	0.508	0.462	0.875

TABLE XVIII (cont'd)

CHARACTERISTIC VALUES						
	RUN 34		RUN 22		RUN 7	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.238	-0.075	*	*	0.214	0.075
$\frac{dC_p}{d(t/t')} = 0$	0.488	-0.575			0.286	1.300
$C_p =$ CONST.	1.250	-0.400			1.012	0.900

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XIX

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 70 ft/sec SENSOR II

	RUN 34 $t' = 0.40$ sec		RUN 22 $t' = 0.39$ sec		RUN 7 $t' = 0.42$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.075	0.000	-0.037	0.000	0.000
0.05	0.020	-0.075	0.020	-0.037	0.021	0.000
0.10	0.040	-0.075	0.039	-0.037	0.042	0.026
0.15	0.060	-0.075	0.059	-0.037	0.063	0.100
0.20	0.080	-0.073	0.078	-0.025	0.084	0.175
0.25	0.100	-0.050	0.098	0.075	0.105	0.275
0.30	0.120	-0.025	0.117	0.350	0.126	0.450
0.35	0.140	0.025	0.137	0.550	0.147	0.800
0.40	0.160	0.075	0.156	0.700	0.168	1.525
0.45	0.180	-0.325	0.176	0.875	0.189	1.675
0.50	0.200	-1.125	0.195	0.975	0.210	1.725
0.55	0.220	-1.050	0.215	1.175	0.231	1.700
0.60	0.240	-0.800	0.234	1.375	0.252	1.640
0.65	0.260	-0.800	0.254	1.325	0.273	1.550
0.70	0.280	-0.775	0.273	1.175	0.294	1.475
0.75	0.300	-0.750	0.293	1.125	0.315	1.400
0.80	0.320	-0.712	0.312	1.085	0.336	1.325
0.85	0.340	-0.675	0.332	1.050	0.357	1.275
0.90	0.360	-0.625	0.351	1.025	0.378	1.235
0.95	0.380	-0.562	0.371	1.000	0.399	1.200
1.00	0.400	-0.500	0.390	0.975	0.420	1.175
1.05	0.420	-0.450	0.410	0.950	0.441	1.150
1.10	0.440	-0.400	0.429	0.935	0.462	1.140

TABLE XIX (cont'd)

CHARACTERISTIC VALUES						
	RUN 34		RUN 22		RUN 7	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	0.200	-0.037	0.048	0.000
$\frac{dC_p}{d(t/t')}=0$			0.600	1.375	0.500	1.725
C_p = CONST.			1.154	0.935	1.143	1.125

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XX
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 70 ft/sec SENSOR III

	RUN 34 t' = 0.40 sec		RUN 22 t' = 0.39 sec		RUN 7 t' = 0.42 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.310	0.000	0.000	0.000	0.120
0.05	0.020	-0.310	0.020	0.010	0.021	0.120
0.10	0.040	-0.310	0.039	0.050	0.042	0.110
0.15	0.060	-0.310	0.058	0.070	0.063	0.100
0.20	0.080	-0.320	0.078	0.090	0.084	0.090
0.25	0.100	-0.370	0.098	0.120	0.105	0.050
0.30	0.120	-0.490	0.117	0.140	0.126	-0.070
0.35	0.140	-0.570	0.136	0.190	0.147	-0.170
0.40	0.160	-0.590	0.156	0.250	0.168	-0.220
0.45	0.180	-0.570	0.176	0.310	0.189	0.080
0.50	0.200	-0.480	0.195	0.410	0.210	0.780
0.55	0.220	-0.330	0.214	0.510	0.231	1.120
0.60	0.240	-0.130	0.234	0.610	0.252	1.530
0.65	0.260	-0.220	0.254	0.760	0.273	1.910
0.70	0.280	-0.700	0.273	0.840	0.294	1.800
0.75	0.300	-1.530	0.292	1.020	0.315	1.770
0.80	0.320	-1.340	0.312	1.130	0.336	1.670
0.85	0.340	-1.140	0.332	1.180	0.357	1.440
0.90	0.360	-0.970	0.351	1.170	0.378	1.370
0.95	0.380	-0.880	0.370	1.120	0.399	1.370
1.00	0.400	-0.830	0.390	1.070	0.420	1.380
1.05	0.420	-0.800	0.410	1.040	0.441	1.380
1.10	0.440	-0.780	0.429	1.010	0.462	1.400
1.15	0.460	-0.760	0.449	1.000	0.483	1.390
1.20	0.480	-0.740	0.469	0.980		
1.25	0.500	-0.720				

TABLE XX (cont'd)

CHARACTERISTIC VALUES						
	RUN 34		RUN 22		RUN 7	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	*	*	*	*	0.443	0.000
$\frac{dC_p}{d(t/t')} = 0$					0.655	1.920
C_p = CONST.					0.893	1.375

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXI

GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 70 ft/sec SENSOR IV

	RUN 34 $t' = 0.40$ sec		RUN 22 $t' = 0.39$ sec		RUN 7 $t' = 0.42$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	0.125	0.000	0.025
0.05	0.020	0.175	0.020	0.220	0.021	0.255
0.10	0.040	0.380	0.039	0.270	0.042	0.450
0.15	0.060	0.630	0.058	0.250	0.063	0.475
0.20	0.080	0.850	0.078	0.195	0.084	0.495
0.25	0.100	0.550	0.098	0.050	0.105	0.490
0.30	0.120	0.300	0.117	-0.150	0.126	0.480
0.35	0.140	0.200	0.136	-0.275	0.147	0.450
0.40	0.160	0.980	0.156	-0.280	0.168	0.330
0.45	0.180	0.175	0.176	-0.190	0.189	0.075
0.50	0.200	-0.165	0.195	0.000	0.210	-0.305
0.55	0.220	0.075	0.214	0.245	0.231	-0.315
0.60	0.240	0.330	0.234	0.530	0.252	-0.050
0.65	0.260	0.625	0.254	0.550	0.273	0.750
0.70	0.280	0.220	0.273	0.575	0.294	1.165
0.75	0.300	-0.280	0.292	0.750	0.315	1.525
0.80	0.320	-0.575	0.312	0.980	0.336	1.925
0.85	0.340	-0.830	0.332	0.900	0.357	1.725
0.90	0.360	-1.030	0.351	0.895	0.378	1.605
0.95	0.380	-1.250			0.399	1.580
1.00	0.400	-1.350			0.420	1.575
1.05	0.420	-1.130				
1.10	0.440	-1.035				
1.15	0.460	-0.980				
1.20	0.480	-0.970				
1.25	0.500	-0.955				

TABLE XXI (cont'd)

CHARACTERISTIC VALUES						
	RUN 34		RUN 22		RUN 7	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	*	*	*	*	*	*
$\frac{dC_p}{d(t/t')} = 0$						
$C_p =$ CONST.						

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXII

GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 100 ft/sec SENSOR I

	RUN 39 $t' = 0.40$ sec		RUN 30 $t' = 0.34$ sec		RUN 10 $t' = 0.40$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.200	0.000	-0.025	0.000	0.110
0.10	0.040	-0.100	0.034	-0.025	0.040	0.110
0.20	0.080	-0.030	0.068	-0.025	0.080	0.100
0.30	0.120	-0.125	0.102	0.125	0.120	0.375
0.40	0.160	-0.500	0.136	0.000	0.160	1.100
0.50	0.200	-0.725	0.170	0.750	0.200	1.375
0.60	0.240	-0.475	0.204	0.800	0.240	1.240
0.70	0.280	-0.400	0.238	0.850	0.280	1.120
0.80	0.320	-0.375	0.272	0.845	0.320	1.050
0.90	0.360	-0.375	0.306	0.720	0.360	1.000
1.00	0.400	-0.362	0.340	0.675	0.400	0.980
1.10	0.440	-0.362	0.374	0.650	0.440	0.975

TABLE XXII (cont'd)

CHARACTERISTIC VALUES						
	RUN 39		RUN 30		RUN 10	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.200	-0.100	*	*	0.110	0.250
$\frac{dC_p}{d(t/t')} = 0$	0.500	-0.725			0.510	1.375
$C_p =$ CONST.	1.625	-0.250			1.025	0.975

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXIII
GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 100 ft/sec SENSOR II

	RUN 39 $t' = 0.40$ sec		RUN 30 $t' = 0.34$ sec		RUN 10 $t' = 0.40$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.075	0.000	0.000	0.000	0.000
0.05	0.020	-0.075	0.017	0.000	0.020	0.000
0.10	0.040	-0.100	0.034	0.000	0.040	0.000
0.15	0.060	-0.125	0.051	0.000	0.060	0.025
0.20	0.080	-0.175	0.068	0.000	0.080	0.100
0.25	0.100	-0.250	0.085	0.000	0.100	0.175
0.30	0.120	-0.400	0.102	-0.050	0.120	0.250
0.35	0.140	-0.625	0.119	-0.125	0.140	0.825
0.40	0.160	-0.800	0.136	0.000	0.160	1.425
0.45	0.180	-0.900	0.153	0.500	0.180	1.875
0.50	0.200	-0.900	0.170	0.850	0.200	1.925
0.55	0.220	-0.750	0.187	1.175	0.220	1.825
0.60	0.240	-0.650	0.204	1.450	0.240	1.650
0.65	0.260	-0.600	0.221	1.375	0.260	1.525
0.70	0.280	-0.537	0.238	1.220	0.280	1.410
0.75	0.300	-0.497	0.255	1.350	0.300	1.375
0.80	0.320	-0.450	0.272	1.325	0.320	1.350
0.85	0.340	-0.412	0.289	1.225	0.340	1.325
0.90	0.360	-0.397	0.306	1.150	0.360	1.300
0.95	0.380	-0.362	0.323	1.075	0.380	1.287
1.00	0.400	-0.337	0.340	1.050	0.400	1.275
1.05	0.420	-0.325	0.357	1.050	0.420	1.250
1.10	0.440	-0.300	0.374	1.050	0.440	1.250

TABLE XXII (cont'd)

CHARACTERISTIC VALUES						
	RUN 39		RUN 30		RUN 10	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	*	*	0.397	-0.010	0.082	0.000
$\frac{dC_p}{d(t/t')} = 0$			0.600	1.450	0.500	1.925
C_p = CONST.			1.000	1.050	1.750	1.125

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXIV
GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 100 ft/sec SENSOR III

	RUN 39 $t' = 0.40$ sec		RUN 30 $t' = 0.34$ sec		RUN 10 $t' = 0.40$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.070	0.000	-0.090	0.000	0.100
0.05	0.020	-0.070	0.017	-0.090	0.020	0.050
0.10	0.040	-0.070	0.034	-0.090	0.040	0.040
0.15	0.060	-0.080	0.051	-0.070	0.060	0.060
0.20	0.080	-0.070	0.068	0.050	0.080	0.080
0.25	0.100	-0.060	0.085	0.300	0.100	0.100
0.30	0.120	0.050	0.102	0.320	0.120	0.170
0.35	0.140	0.190	0.119	0.180	0.140	0.280
0.40	0.160	0.380	0.136	-0.030	0.160	0.390
0.45	0.180	-0.030	0.153	-0.080	0.180	0.540
0.50	0.200	-0.360	0.170	0.080	0.200	0.770
0.55	0.220	-0.530	0.187	0.260	0.220	1.450
0.60	0.240	-0.650	0.204	0.400	0.240	1.810
0.65	0.260	-0.740	0.221	0.560	0.260	1.700
0.70	0.280	-0.730	0.238	0.620	0.280	1.620
0.75	0.300	-0.630	0.255	0.920	0.300	1.580
0.80	0.320	-0.570	0.272	1.150	0.320	1.540
0.85	0.340	-0.530	0.289	1.140	0.340	1.520
0.90	0.360	-0.510	0.306	1.080	0.360	1.500
0.95	0.380	-0.490	0.323	1.030	0.380	1.480
1.00	0.400	-0.470	0.340	1.000	0.400	1.470
1.05	0.420	-0.440	0.357		0.420	1.440
1.10	0.440	-0.430	0.374		0.440	1.430

TABLE XXIV (cont'd)

CHARACTERISTIC VALUES						
	RUN 39		RUN 30		RUN 10	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	*	*	*	*	0.075	0.050
$\frac{dC_p}{d(t/t')} = 0$					0.595	1.820
C_p = CONST.					1.750	1.430

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXV
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 100 ft/sec SENSOR IV

	RUN 39 $t' = 0.40$ sec		RUN 30 $t' = 0.34$ sec		RUN 10 $t' = 0.40$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.060	0.000	-0.085	0.000	0.000
0.05	0.020	0.060	0.017	-0.075	0.020	0.000
0.10	0.040	0.055	0.034	-0.040	0.040	0.000
0.15	0.060	0.095	0.051	0.015	0.060	0.030
0.20	0.080	0.070	0.068	0.155	0.080	0.055
0.25	0.100	0.015	0.085	0.150	0.100	0.080
0.30	0.120	-0.175	0.102	0.170	0.120	0.120
0.35	0.140	-0.330	0.119	0.170	0.140	0.180
0.40	0.160	-0.585	0.136	0.170	0.160	0.265
0.45	0.180	-0.620	0.153	0.175	0.180	0.335
0.50	0.200	-0.415	0.170	0.175	0.200	0.420
0.55	0.220	0.000	0.187	0.185	0.220	0.500
0.60	0.240	0.705	0.204	0.200	0.240	0.585
0.65	0.260	0.275	0.221	0.260	0.260	0.680
0.70	0.280	-0.600	0.238	0.435	0.280	0.775
0.75	0.300	-0.100	0.255	0.550	0.300	0.870
0.80	0.320	-0.365	0.272	0.650	0.320	1.005
0.85	0.340	-0.975	0.289	0.765	0.340	1.155
0.90	0.360	-1.060	0.306	1.055	0.360	1.335
0.95	0.380	-0.990	0.323	0.860	0.380	1.815
1.00	0.400	-0.955	0.340	0.855	0.400	1.765
1.05	0.420	-0.935	0.357	0.855	0.420	1.575
1.10	0.440	-0.920	0.374		0.440	1.555

TABLE XXV (cont'd)

CHARACTERISTIC VALUES						
	RUN 39		RUN 30		RUN 10	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	*	*	*	*
$\frac{dC_p}{d(t/t')}=0$						
$C_p =$ CONST.						

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXVI

GENERAL PRESSURE COEFFICIENT - T.ME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 130 ft/sec SENSOR I

	RUN 42 t' = 0.30 sec		RUN 51 t' = 0.29 sec		RUN 14 t' = 0.30 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.075	0.000	-0.025	0.000	0.200
0.05	0.015	-0.075	0.015	-0.025	0.015	0.120
0.10	0.030	-0.075	0.029	-0.025	0.030	0.060
0.15	0.045	-0.070	0.044	-0.025	0.045	0.070
0.20	0.060	-0.070	0.058	-0.075	0.060	0.100
0.25	0.075	-0.075	0.073	-0.050	0.075	0.300
0.30	0.090	-0.150	0.087	0.100	0.090	0.550
0.35	0.105	-0.300	0.102	0.270	0.105	0.800
0.40	0.120	-0.650	0.116	0.470	0.120	1.050
0.45	0.135	-0.650	0.131	0.725	0.135	1.180
0.50	0.150	-0.460	0.145	1.075	0.150	1.220
0.55	0.165	-0.425	0.160	1.120	0.165	1.180
0.60	0.180	-0.410	0.174	0.950	0.180	1.120
0.65	0.195	-0.380	0.189	0.780	0.195	1.080
0.70	0.210	-0.375	0.203	0.720	0.210	1.030
0.75	0.225	-0.375	0.218	0.680	0.225	1.000
0.80	0.240	-0.375	0.232	0.660	0.240	0.970
0.85	0.255	-0.360	0.247	0.640	0.255	0.950
0.90	0.270	-0.350	0.261	0.620	0.270	0.920
0.95	0.285	-0.350	0.276	0.600	0.285	0.920
1.00	0.300	-0.350	0.290	0.600	0.300	0.900
1.05	0.315	-0.330	0.304	0.575	0.315	0.880
1.10	0.330	-0.320	0.319	0.575	0.330	0.870
1.15	0.345	-0.300	0.334	0.575	0.345	0.860
1.20	0.360	-0.300	0.348	0.550	0.360	0.850

TABLE XXVI (cont'd)

CHARACTERISTIC VALUES						
	RUN 42		RUN 51		RUN 14	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	0.267	-0.075	*	*	0.203	0.125
$\frac{dC_p}{d(t/t')}=0$	0.430	-0.750			0.480	1.220
$C_p =$ CONST.	1.167	-0.255			0.850	1.200

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXVII

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 130 ft/sec SENSOR II

	RUN 42 t' = 0.30 sec		RUN 51 t' = 0.29 sec		RUN 14 t' = 0.30 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	0.000	0.000	0.025
0.05	0.150	0.000	0.015	0.000	0.015	0.050
0.10	0.030	0.000	0.029	0.000	0.030	0.050
0.15	0.045	0.000	0.044	0.000	0.045	0.062
0.20	0.060	-0.025	0.058	0.000	0.060	0.075
0.25	0.075	-0.075	0.072	0.000	0.075	0.100
0.30	0.090	-0.150	0.087	-0.325	0.090	0.200
0.35	0.105	-0.250	0.102	0.100	0.105	0.400
0.40	0.120	-0.500	0.116	0.475	0.120	1.025
0.45	0.135	-1.000	0.131	0.975	0.135	1.800
0.50	0.150	-0.950	0.145	1.350	0.150	1.975
0.55	0.165	-0.825	0.160	1.370	0.165	1.900
0.60	0.180	-0.700	0.174	1.170	0.180	1.725
0.65	0.195	-0.625	0.189	1.050	0.195	1.575
0.70	0.210	-0.575	0.203	1.020	0.210	1.475
0.75	0.225	-0.500	0.218	1.010	0.225	1.400
0.80	0.240	-0.450	0.232	1.000	0.240	1.370
0.85	0.255	-0.425	0.247	1.000	0.255	1.350
0.90	0.270	-0.400	0.261	1.000	0.270	1.335
0.95	0.285	-0.375	0.276	1.000	0.285	1.325
1.00	0.300	-0.350	0.290	1.000	0.300	1.325
1.05	0.315	-0.325	0.305		0.315	1.325
1.10	0.330	-0.300	0.319		0.330	1.320
1.15	0.345	-0.280	0.335		0.345	1.320
1.20	0.360	-0.280	0.342		0.360	1.300

TABLE XXVII (cont'd)

CHARACTERISTIC VALUES						
	RUN 42		RUN 51		RUN 14	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	0.328	-0.100	0.000	0.025
$\frac{dC_p}{d(t/t')}=0$			0.510	1.375	0.500	1.975
C_p = CONST.			0.793	1.000	2.000	1.167

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXVIII

GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 130 ft/sec SENSOR III

	RUN 42 t' = 0.30 sec		RUN 51 t' = 0.29 sec		RUN 14 t' = 0.30 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.130	0.000	-0.050	0.000	0.090
0.05	0.015	-0.110	0.015	-0.050	0.015	0.100
0.10	0.030	-0.120	0.029	-0.040	0.030	0.100
0.15	0.045	-0.150	0.044	-0.050	0.045	0.100
0.20	0.060	-0.220	0.058	-0.060	0.060	0.110
0.25	0.075	-0.290	0.073	-0.090	0.075	0.270
0.30	0.090	-0.320	0.087	-0.180	0.090	0.620
0.35	0.105	-0.250	0.102	-0.290	0.105	0.730
0.40	0.120	-0.190	0.116	-0.210	0.120	0.330
0.45	0.135	-0.210	0.131	0.050	0.135	0.080
0.50	0.150	-0.300	0.145	0.370	0.150	0.670
0.55	0.165	-0.490	0.160	0.730	0.165	1.430
0.60	0.180	-0.670	0.174	0.890	0.180	1.610
0.65	0.195	-0.820	0.189	0.940	0.195	1.580
0.70	0.210	-0.690	0.203	0.970	0.210	1.490
0.75	0.225	-0.630	0.218	0.960	0.225	1.440
0.80	0.240	-0.620	0.232	0.930	0.240	1.410
0.85	0.255	-0.600	0.247	0.910	0.255	1.390
0.90	0.270	-0.590	0.261	0.900	0.270	1.380
0.95	0.285	-0.570	0.276	0.890	0.285	1.370
1.00	0.300	-0.550	0.290	0.890	0.300	1.350
1.05	0.315	-0.530	0.305	0.890	0.315	1.340
1.10	0.330	-0.530	0.319	0.890	0.330	1.330
1.15	0.345	-0.520	0.334	0.890	0.345	1.330
1.20	0.360	-0.510	0.348	0.890	0.360	1.330

TABLE XXVIII (cont'd)

CHARACTERISTIC VALUES						
	RUN 42		RUN 51		RUN 14	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	*	*	0.223	0.100
$\frac{dC_p}{d(t/t')}=0$					0.600	1.610
$C_p =$ CONST.					1.417	1.300

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXIX

GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 130 ft/sec SENSOR IV

	RUN 42 t' = 0.30 sec		RUN 51 t' = 0.29 sec		RUN 14 t' = 0.30 sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.175	0.000	-0.100	0.000	0.000
0.05	0.015	-0.175	0.015	0.075	0.015	0.037
0.10	0.030	-0.175	0.029	0.175	0.030	0.075
0.15	0.045	-0.225	0.044	0.287	0.045	0.125
0.20	0.060	-0.400	0.058	0.325	0.060	0.175
0.25	0.075	-0.550	0.073	0.275	0.075	0.250
0.30	0.090	-0.725	0.087	-0.125	0.090	0.350
0.35	0.105	-0.875	0.102	-0.525	0.105	0.475
0.40	0.120	-0.925	0.116	-0.550	0.120	0.513
0.45	0.135	-0.825	0.131	0.050	0.135	0.800
0.50	0.150	-0.250	0.145	0.200	0.150	0.900
0.55	0.165	0.125	0.160	0.350	0.165	1.025
0.60	0.180	-0.250	0.174	0.425	0.180	1.125
0.65	0.195	-0.450	0.189	0.462	0.195	1.200
0.70	0.210	-0.580	0.203	0.550	0.210	1.275
0.75	0.225	-0.675	0.218	0.600	0.225	1.325
0.80	0.240	-0.762	0.232	0.650	0.240	1.330
0.85	0.255	-0.812	0.247	0.700	0.255	1.350
0.90	0.270	-0.862	0.261	0.740	0.270	1.337
0.95	0.285	-0.900	0.276	0.775	0.285	1.325
1.00	0.300	-0.920	0.290	0.800	0.300	1.300
1.05	0.315	-0.920	0.305	0.787	0.315	1.300
1.10	0.330	-0.900	0.319	0.750	0.330	1.300
1.15	0.345	-0.900	0.334	0.725	0.345	
1.20	0.360	-0.900	0.348	0.710	0.360	

TABLE XXIX (cont'd)

CHARACTERISTIC VALUES						
	RUN 42		RUN 51		RUN 14	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$ $\frac{dC_p}{d(t/t')}=0$ $C_p =$ CONST.	*	*	*	*	*	*

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXX

GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 160 ft/sec SENSOR I

	RUN 47 $t' = 0.30$ sec		RUN 26 $t' = 0.25$ sec		RUN 18 $t' = 0.28$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	-0.062	0.000	0.125
0.05	0.015	0.000	0.013	-0.050	0.014	0.125
0.10	0.030	0.000	0.025	-0.050	0.028	0.225
0.15	0.045	0.000	0.038	-0.050	0.042	0.400
0.20	0.060	-0.050	0.050	-0.070	0.056	0.700
0.25	0.075	-0.070	0.063	-0.075	0.070	0.900
0.30	0.090	-0.125	0.075	0.150	0.084	1.150
0.35	0.105	-0.450	0.082	0.875	0.098	1.290
0.40	0.120	-0.900	0.100	1.025	0.112	1.310
0.45	0.135	-0.625	0.113	1.030	0.126	1.275
0.50	0.150	-0.750	0.125	0.900	0.140	1.220
0.55	0.165	-0.775	0.138	0.775	0.154	1.170
0.60	0.180	-0.750	0.150	0.700	0.168	1.120
0.65	0.195	-0.675	0.163	0.700	0.182	1.080
0.70	0.210	-0.600	0.175	0.680	0.196	1.040
0.75	0.225	-0.565	0.188	0.680	0.210	1.000
0.80	0.240	-0.550	0.200	0.680	0.224	0.980
0.85	0.255	-0.525	0.213		0.238	0.970
0.90	0.270	-0.512	0.225		0.252	0.950
0.95	0.285	-0.485	0.238		0.266	0.940
1.00	0.300	-0.475	0.250		0.280	0.930
1.05	0.315	-0.470	0.263		0.294	0.925
1.10	0.330	-0.462	0.275		0.308	0.920
1.15	0.345	-0.450	0.288		0.322	0.915
1.20	0.360	-0.450	0.300		0.336	0.910

TABLE XXX (cont'd)

CHARACTERISTIC VALUES						
	RUN 47		RUN 26		RUN 18	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	0.167	0.000	*	*	0.036	0.125
$\frac{dC_p}{d(t/t')} = 0$	0.400	-0.900			0.410	1.320
C_p = CONST.	1.667	-0.511			1.321	0.900

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXXI

GENERAL PRESSURE COEFFICIENT-TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 160 ft/sec SENSOR II

	RUN 47 $t' = 0.30$ sec		RUN 26 $t' = 0.25$ sec		RUN 18 $t' = 0.28$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	0.000	0.000	-0.025	0.000	0.000
0.05	0.015	0.000	0.013	-0.025	0.014	0.000
0.10	0.030	0.000	0.025	-0.025	0.028	0.050
0.15	0.045	-0.025	0.038	-0.025	0.042	0.120
0.20	0.060	-0.075	0.050	-0.050	0.056	0.250
0.25	0.075	-0.150	0.063	-0.110	0.070	0.425
0.30	0.090	-0.325	0.075	-0.150	0.084	0.750
0.35	0.105	-0.625	0.088	0.000	0.098	1.400
0.40	0.120	-1.525	0.100	0.600	0.112	1.630
0.45	0.135	-1.175	0.113	1.330	0.126	1.675
0.50	0.150	-0.900	0.125	1.362	0.140	1.600
0.55	0.165	-0.770	0.138	1.350	0.154	1.450
0.60	0.180	-0.675	0.150	1.280	0.168	1.375
0.65	0.195	-0.600	0.163	1.250	0.182	1.330
0.70	0.210	-0.550	0.175	1.220	0.196	1.275
0.75	0.225	-0.500	0.188	1.200	0.210	1.250
0.80	0.240	-0.480	0.200	1.175	0.224	1.225
0.85	0.255	-0.475	0.213	1.175	0.238	1.200
0.90	0.270	-0.462	0.225	1.150	0.252	1.190
0.95	0.285	-0.462	0.238	1.140	0.266	1.180
1.00	0.300	-0.462	0.250	1.130	0.280	1.175
1.05	0.315	-0.450	0.263	1.125	0.294	1.175
1.10	0.330	-0.430	0.275	1.125	0.308	1.170
1.15	0.345	-0.425	0.288	1.125	0.322	1.170
1.20	0.360	-0.425	0.300	1.120	0.336	1.170

TABLE XXXI (cont'd)

CHARACTERISTIC VALUES						
	RUN 47		RUN 26		RUN 18	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	0.283	-0.050	0.046	0.000
$\frac{dC_p}{d(t/t')}=0$			0.500	1.362	0.400	1.675
C_p = CONST.			1.300	1.100	1.607	1.125

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXXII
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 160 ft/sec SENSOR III

	RUN 47 $t'=0.30$ sec		RUN 26 $t'=0.25$ sec		RUN 18 $t'=0.28$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.090	0.000	-0.040	0.000	0.000
0.05	0.015	-0.090	0.013	-0.050	0.014	0.000
0.10	0.030	-0.080	0.025	-0.070	0.028	0.000
0.15	0.045	-0.050	0.038	-0.100	0.042	0.020
0.20	0.060	0.030	0.050	-0.130	0.056	0.060
0.25	0.075	0.110	0.063	-0.200	0.070	0.090
0.30	0.090	0.220	0.075	-0.260	0.084	0.160
0.35	0.105	0.330	0.088	-0.280	0.098	0.250
0.40	0.120	-0.210	0.100	-0.260	0.112	0.530
0.45	0.135	-0.490	0.113	-0.060	0.126	0.900
0.50	0.150	-0.900	0.125	0.180	0.140	1.300
0.55	0.165	-1.200	0.138	0.560	0.154	1.560
0.60	0.180	-1.020	0.150	0.910	0.168	1.610
0.65	0.195	-0.850	0.163	1.000	0.182	1.580
0.70	0.210	-0.770	0.175	1.030	0.196	1.520
0.75	0.225	-0.720	0.188	1.020	0.210	1.480
0.80	0.240	-0.690	0.200	1.000	0.224	1.430
0.85	0.255	-0.670	0.213	0.980	0.238	1.410
0.90	0.270	-0.650	0.225	0.960	0.252	1.380
0.95	0.285	-0.650	0.238	0.960	0.266	1.360
1.00	0.300	-0.640	0.250	0.950	0.280	1.290
1.05	0.315	-0.630	0.263	0.940	0.294	1.280
1.10	0.330	-0.620	0.275	0.930	0.308	1.260
1.15	0.345	-0.610	0.288	0.930	0.322	1.240
1.20	0.360	-0.600	0.300	0.930	0.336	1.230

TABLE XXXII (cont'd)

CHARACTERISTIC VALUES						
	RUN 47		RUN 26		RUN 18	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')} > 0$	*	*	*	*	0.125	0.000
$\frac{dC_p}{d(t/t')} = 0$					0.600	1.610
$C_p =$ CONST.					1.571	1.250

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

TABLE XXXIII
GENERAL PRESSURE COEFFICIENT - TIME RELATIONSHIP AND CHARACTERISTIC DATA FOR ARRANGEMENT OF REPLACEMENT CURVE (EXTRACTED FROM REF 1)

RINGSLOT PARACHUTE

VELOCITY = 160 ft/sec SENSOR IV

	RUN 47 $t' = 0.30$ sec		RUN 26 $t' = 0.25$ sec		RUN 18 $t' = 0.28$ sec	
t/t'	t (sec)	C_{p_e}	t (sec)	C_{p_i}	t (sec)	C_{p_d}
0.00	0.000	-0.050	0.000	0.000	0.000	0.000
0.05	0.015	0.025	0.013	0.100	0.014	0.000
0.10	0.030	0.175	0.025	0.225	0.028	0.050
0.15	0.045	0.350	0.038	0.375	0.042	0.075
0.20	0.060	0.550	0.050	0.475	0.056	0.135
0.25	0.075	0.625	0.063	0.475	0.070	0.175
0.30	0.090	0.400	0.075	0.250	0.084	0.225
0.35	0.105	0.100	0.088	-0.312	0.098	0.275
0.40	0.120	-0.200	0.100	-0.300	0.112	0.320
0.45	0.135	-0.550	0.113	-0.125	0.126	0.375
0.50	0.150	-0.950	0.125	0.175	0.140	0.450
0.55	0.165	-0.850	0.138	0.400	0.154	0.525
0.60	0.180	-0.787	0.150	0.525	0.168	0.695
0.65	0.195	-0.812	0.163	0.600	0.182	0.700
0.70	0.210	-0.925	0.175	0.650	0.196	0.825
0.75	0.225	-1.187	0.188	0.695	0.210	0.975
0.80	0.240	-1.125	0.200	0.740	0.224	1.175
0.85	0.255	-1.000	0.213	0.787	0.238	1.425
0.90	0.270	-0.925	0.225	0.835	0.252	1.325
0.95	0.285	-0.875	0.238	0.865	0.266	1.285
1.00	0.300	-0.850	0.250	0.875	0.280	1.275
1.05	0.315	-0.837	0.263	0.875	0.294	1.262
1.10	0.330	-0.825	0.275	0.865	0.308	1.250
1.15	0.345	-0.825	0.288	0.850	0.322	1.250
1.20	0.360	-0.820	0.300	0.850	0.336	1.250

TABLE XXXIII (cont'd)

CHARACTERISTIC VALUES						
	RUN 47		RUN 26		RUN 18	
	t/t'	C_{p_e}	t/t'	C_{p_i}	t/t'	C_{p_d}
$\frac{dC_p}{d(t/t')}>0$	*	*	*	*	*	*
$\frac{dC_p}{d(t/t')}=0$						
$C_p =$ CONST.						

* REPLACEMENT CURVE DETERMINED BY COMPUTER FOR THIS SENSOR

SECTION IV

The following Table XXXIV shows the averaged drag coefficients for the solid flat circular, and ringslot parachute models based on the force data contained in Ref 2 and related to areas reported in Ref 1 and measured from the model canopies.

TABLE XXXIV

COMPARISON OF DRAG COEFFICIENTS BASED ON NOMINAL AREA (REF 1) AND MEASURED AREA

Parachute	Diameter, D_o (in)		Area, S (ft^2)		Drag Area (ft^2)	Drag Coefficient	
	①	②	③	④	⑤	⑥	⑦
	Ref 1	Measured	Ref 1	Measured	Derived *	Ref 1 **	Measured ***
Solid Flat Circular	[illegible]	4[illegible].0	1[illegible].61	[illegible]	11.4[illegible]	[illegible].7[illegible]	0.[illegible]7
Ringslot	5[illegible].5	[illegible]0.0	1[illegible].61	13.72	6.45	0.4[illegible]	0.47

$$*\ (C_DS)_{av} = \frac{1}{n}\sum_{n}\frac{F_n}{q_n} \qquad **\ C_{D\,av} = \frac{(C_DS)_{av}}{③} \qquad ***\ C_{D\,av} = \frac{(C_DS)_{av}}{④}$$

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